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Spaceflight

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COMET 1956h AREND-ROLAND.

Photographed from Westcliff-on-Sea, 1957, April 29, 21.05 U.T. (f 15.6 Aircraft camera lens—14¼ inches f.l. H.P.3 plate + Ilford Micro 5 deep orange filter (5700 – 6700 Å). Exposure 30 minutes.

North at top—scale approx. |—1°—|
Enlarged × 5.

M. J. HENDRIE

Editorial

On October 4, 1957, Russian scientists successfully launched the first Earth Satellite. The news was first given by Moscow Radio just before midnight, and it was not long before radio signals from the orbiting vehicle were picked up in many parts of the world.

Scientists in all countries will be eager to congratulate the Soviet workers upon their magnificent achievement. At last the artificial moon exists in fact as well as in theory, and it seems appropriate to quote the words broadcast by Moscow Radio: "The successful launching of the first man-made satellite of the Earth constitutes a major contribution to world science and culture. . . . Artificial satellites will pave the way to interplanetary travel."

The news was received just as the present issue of SPACEFLIGHT was in the final stages of publication. At the time of writing (October 5) full details are naturally not available, and rather than risk printing anything which the Russians themselves do not confirm as being entirely accurate it seems best to postpone any discussion of the new project until our next issue.

Meanwhile, there can be no doubt that all members of the British Interplanetary Society will want to express their appreciation of what the Russians have done. Their feat is indeed among the most notable in all scientific history.

PATRICK MOORE, *Editor*

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The International Astronautical Federation

L. R. SHEPHERD (PRESIDENT 1956–57)

Historical Introduction

The I.A.F. was founded in London in September, 1951, during the Second International Astronautical Congress. Its history started, however, two years earlier at the 1949 Summer Meeting of the, then, newly-formed Astronautical Society of Western Germany, the "Gesellschaft fur Weltraumforschung", when the following resolution was passed:—

"The development of the large liquid-fuel rocket has advanced so far that the question of spaceflight now arises and its practicability can be confidently affirmed.

The rocket is not only a weapon, but also an instrument of peaceful research. The G.f.W. therefore considers one of its most important tasks to be the emphasis of the peaceful possibilities of space travel and the promotion of spaceflight as a new means of research.

The drive towards interplanetary space and future research on spaceflight are international tasks. Cooperation between scientists and engineers of all nations culminated in the present successful position.

The G.f.W. therefore recommends an international meeting of all societies for rocket development, interplanetary travel and space research, to foster friendly relations and a successful exchange of knowledge, and to explore the possibilities of forming an international association for astronautics."

The resolution dated June 22, 1949, was signed on behalf of the G.f.W. Board of Directors, by H. Gartmann, the Technical Director, and H. H. Koelle, the Secretary of the Society. It was communicated immediately to the Council of the British Interplanetary Society, with whom there existed close and cordial relations, accompanied by a proposal that steps should be taken to hold the international meeting envisaged in the resolution and to set up an international society devoted to astronautics. The suggestion was received with great interest by the B.I.S. Council and a reply indicating its general agreement with the principles of the G.f.W. resolution was sent to the German Society.

Correspondence on the proposed international organization developed, notably between the G.f.W., the B.I.S. and the Groupement Astronautique Française. It was the wish of the G.f.W. that the first meeting should be held in London, but the B.I.S. considered that they would need two years to develop the organization of the international body and prepare a full-scale international conference. Finally, it was agreed that a preliminary meeting should be held in Paris in 1950, under the presidency of M. Alexandre Ananoff, the leader of the French Group. As it turned out the Paris meeting was organized by M. Ananoff on a far from modest scale and it has been rightly counted, subsequently, as the First International Astronautical Congress.

It is worth noting that at the time when the G.f.W. made its proposals there were known to be recognized astronautical or rocket societies in Argentina, Canada, Denmark, Germany, United Kingdom and the United States of America. In America there existed no less than five societies of which the major body was the American Rocket Society. The situation in Germany was confused by the fact that the G.f.W. really consisted of three autonomous groups which, in fact, were not united into a common body for some years. Other countries were known to be forming astronautical societies and by the time the I.A.F. came into being the list of societies had increased considerably. During the early years of the I.A.F., attempts to establish contact with possible Russian groups or societies in other countries coming within the Soviet sphere were not successful despite repeated attempts, so that the true international picture of spaceflight developments was not revealed.

The Paris Congress was held from September 30 to October 2, 1950, inclusively. A. Ananoff, the organizer, was President of the Congress and the official delegates included Tabanera, representing the Argentina Society; Cap, Rückert and Schmiedl from the Austrian G.f.W.; Hansen from the Danish Society for Spaceflight Research; Loeser, Koelle and Brugel from the Stuttgart G.f.W.; Jungklaass and Oesterwinter representing the Hamburg G.f.W.; Mur from the Spanish Astronautical Society; Hjerstrand representing a Swedish Group which was in the process of forming a society and Cleaver, Clarke, Burgess, Humphries and Shepherd representing the B.I.S. A number of independent observers, notably Sänger, Frau Dr. Bredt, Engels and Nebel, also took part in the meetings. An interesting commentary on the state of international affairs, even as recently as 1950, lay in the fact that a number of German and Swiss representatives were prevented from attending the Congress due to delays in obtaining visas.

The opening meeting of the Congress on September 30 was an impressive public gathering at the Richelieu Grand Amphitheatre of the Sorbonne. It was attended by a very large audience, stated to have numbered about 1,000, and was presided over by Henry Mineur, Director of the French Institute of Astrophysics. This meeting, at which leading public figures outside the astronautics sphere were invited to address the audience, has formed the pattern for nearly all subsequent congresses.

No attempt was made to hold a technical symposium at the Paris Congress. Apart from the public opening ceremony, the time was taken up by business meetings to work out plans for the future form of international collaboration between the national astronautics groups. These meetings were held at the French Aero Club on October 1 and 2, under the chairmanship of Dr. Loeser and Mr. A. V. Cleaver, who were respectively heads of G.f.W. and B.I.S. delegations. They were conducted in three languages: French, German and English, with Cap, Loeser and Koelle acting as interpreters in addition to the official interpreter (Mme Fondere). It was clear that very wide differences of opinion existed with regard to the scope and size of the proposed international body. One view was that the federation should be a very powerful organization associated with a financial holding company capable of financing research and development. However, in the majority view the proposed international body was envisaged as being a much more conservative federation of the various national societies, serving largely as a medium for liaison and collaboration between these societies and other groups engaged in the study or development of astronautics. At the same time many of the representatives hoped that it might eventually become more than this, perhaps participating in a positive manner in an international project to advance the science and technology of spaceflight.

At the close of the Paris Congress the assembled delegates resolved unanimously that:—

(i) An international astronautical organization should be created.

(ii) This "International Federation of Astronautical Societies" should be inaugurated at a second congress to be held in London in the following year.

(iii) In the intervening period the representatives of the individual national societies should contribute suggestions relating to the foundation and organization of the federation.

(iv) The British Interplanetary Society, in their capacity as organizers of the Second Congress, would undertake the co-ordination of all the proposals submitted.

(v) It was intended that the functions and constitution of the proposed International Federation, should be worked out prior to the London Congress. The business at that Congress would be devoted to the discussion and acceptance of the proposals in their final form, after which the Federation would be formally inagurated.

(vi) In the interim, a provisional committee consisting of the chief delegates at Paris, under Dr. Eugen Sänger, would act as a body responsible for international co-operation, pending the formal setting-up of the Federation.

During the intervening year between the Paris and London Congresses, considerable correspondence was exchanged relating to the organization of the Federation. The greater part of this was between the G.f.W. and the B.I.S., with Dr. Loeser for the former and Mr. Cleaver, on behalf of the latter, playing major parts in drawing up the proposals that were to be put before the London Congress. As an outcome of this exchange of views the B.I.S. circulated a draft Constitution in May, 1951, about four months prior to the Congress.

The Second International Astronautical Congress was held in London, at Caxton Hall, during the week commencing September 3, 1951. Altogether about 40 overseas visitors, representing societies in Argentina, Austria, France, Germany, Holland, Italy, Spain, Sweden, Switzerland and the U.S.A., attended, as well as members of the British host Society. The working sessions were held during the first two days of the Congress and the delegates were welcomed by Mr. A. C. Clarke, the B.I.S. Chairman, who handed over the Chair, to Dr. Sänger, to conduct the subsequent business.

Broadly speaking, the assembled delegates gave their approval to the proposals that had been drawn up over the preceding year, but there were points of disagreement which held up the final acceptance of the Constitution until the Third Congress at Stuttgart in the following year. Despite this postponement, the Federation, which was given the title "International Astronautical Federation", was formally inaugurated and the Societies represented at London became its founder members. Dr. Eugen Sänger was elected to be the first President of the I.A.F. and Dr. G. Loeser of the G.f.W., and Mr. Andrew G. Haley (who led the A.R.S. delegation), were elected Vice-Presidents. (According to the constitution of the I.A.F., as it was subsequently adopted, one of the Vice-Presidents must be a representative of that Society responsible for the organization of the succeeding Congress.) It was decided that the I.A.F. should be based in Switzerland and, accordingly, Ing. J. Stemmer, the Swiss delegate, was elected Honorary Secretary with the duty of setting up a central office. One of the main tasks of the International Astronautical Federation, would be the holding of annual international astronautical congresses. The officers of the Federation were to be elected annually and would hold office from the conclusion of the business sessions, at which they were elected to the end of the corresponding sessions at the subsequent Congress.

It is interesting to note that the main factor which held up the acceptance of the I.A.F. Constitution at London was related to the question of voting rights. Particularly strong views were expressed on this matter and it was not found possible at London to come to a permanent agreement, a temporary solution, whereby each society should have one vote, being adopted. Subsequently (at Stuttgart) it was accepted that only one society in any country could have a vote and it was a matter for the I.A.F. Council to decide which societies were eligible to be voting-members of the Federation and which should be non-voting-members.

The Constitution and Objectives of the I.A.F.

The International Astronautical Federation is an association of interplanetary and rocket societies from all parts of the world. At the time of writing the total number of organizations belonging to the Federation stands at twenty-five, which are listed at the end of this article. They fall into three categories, namely: Voting members, Non-voting members and Institution members. The difference between Voting members and Non-voting members is that the former are represented on the Council of the I.A.F., while the latter although they may participate in the plenary meetings of the Council are not allowed to vote on any issue except by invitation of the Council. Institution membership is open to technical and scientific institutions which are interested in astronautics, but not necessarily devoted to its pursuit. Members of the last class may participate in the plenary sessions of the I.A.F. only by special invitation of the Council, but such participation does not include any right to vote.

The governing body of the International Astronautical Federation is its Council, which consists of one delegate from each voting-member Society. Normally, of course, each delegate is accompanied by an assistant who may speak in his place during discussions. It is also normal procedure for the delegates of non-voting member Societies to sit at the Council table and participate freely in the business transacted.

The chief officers of the I.A.F. are its President, Vice-Presidents and Secretary, who are elected annually at the Congresses. The President and Vice-Presidents, following a resolution at the Rome Congress, may not serve a second successive term, except by unanimous vote of the Council, and under no circumstances may they serve more than two consecutive terms. The Secretary may be re-elected on any occasion and, of course, in the interests of continuity of government he will occupy his office for many years. This, generally, will also apply to other important officials such as the Editor-in-Chief of the Astronautica Acta and Chairmen of Standing Committees.

An office at Baden, Switzerland, run by the Secretary, constitutes the registered permanent headquarters of the Federation. Routine business is conducted throughout the year from this office and the archives and library of the I.A.F. are housed there. At the present time there is no permanent meeting place for the Council or officials. All formal meetings take place once a year at the Congress. Obviously, as the activities of the I.A.F. expand it will be necessary to hold additional meetings. Already, in April of the present year, one such meeting between members of the International Affairs Committee of the I.A.F.

At the final reception of the Rome Congress. Left to right: Dr. Shepherd, F. C. Durant, Mrs. Shepherd, Dr. Th. Von Kármán.

and officials of UNESCO has taken place in Paris. It is anticipated that such "inter-Congress" meetings will become fairly frequent in the future.

According to the articles of its Constitution the International Astronautical Federation exists for the purpose of the promotion and stimulation of work leading to the permanent achievement of spaceflight. This it may do through the medium of its international meetings and publications; by facilitating collaboration between the otherwise independent National Astronautical Societies; by encouraging universities or other research institutions throughout the world to undertake work which is relevant to the progress of astronautics and by any other means that may seem appropriate. A long-term objective of the Federation lies in the possible foundation of an international research institute devoted to astronautics.

The foundation of an international research institute, either within the framework of the I.A.F. or, more probably, as an independent entity having intimate ties with the Federation, is an objective which is particularly desirable to all who are associated with the astronautics movement. The practicability of doing this, however, is a matter of some controversy. Obviously, the possibility must be governed by the international political situation, since many of the technical aspects of spaceflight are closely related to military developments. It is unlikely that a really effective research institute could be set up in the present circumstances, but if international relations were to improve and the nations agreed to disarm on a significant scale, the position would be very different. In these circumstances, the military development of rockets and guided weapons might be so curtailed, on a national scale, that the formation of an international research programme would not only become possible, but might be essential to the achievement of spaceflight.

If it seems that the long-term aim of setting up an international research institute, must, for the time being, remain an unrealizable ambition, there is, nevertheless, a wide field of useful endeavour which is open to the I.A.F. The main concern of the Federation at the present time is the publication of scientific papers and the organization of technical symposia, activities which are the traditional means whereby learned societies contribute to the advancement of science and technology. In the case of the I.A.F. the medium of publication is the *Astronautica Acta* and the technical symposia constitute the main feature of the annual congresses. One should note, of course, that the corresponding activities of individual member societies greatly exceed their joint activities through the I.A.F., though, insofar as the effort is directed towards the common objective of the advancement of astronautics, the distinction between individual and joint activity is not particularly important.

Astronautica Acta

At the Fourth Congress (Zurich, 1953) a committee was set up to study the problem of launching a scientific journal. The terms of reference of this body were that it should consider whether the I.A.F. should assume full responsibility for the publication or allow it to be undertaken by a reputable publishing house, under I.A.F. editorship. The committee was responsible, also, for nominating an editorial board and an advisory panel. It was required to report back to the I.A.F. at the following Congress.

The report of the committee at Innsbruck in 1954 recommended that the publication of an I.A.F. journal, the *Astronautica Acta*, should proceed without delay. A majority of the Committee were in favour of publication being placed in the hands of a well-known publisher, and the firm of Springer-Verlag, who were favourably disposed to the proposition, was recommended. The Committee put forward a list of names for the editorial panel and recommended that Professor Friedrich Hecht, of Vienna, should be Editor-in-Chief.

The recommendations of the Committee were accepted and a contract was drawn up with Springer-Verlag. *Astronautica Acta* first appeared in January, 1955, as a quarterly publication. The first volume contained 16 papers which occupied some 210 pages. The papers included some of the contributions to the Innsbruck and Copenhagen Congresses, the original intention being that selected papers from the congresses should constitute the main material for the journal.

The circulation of the *Acta* has increased steadily since its introduction. At the Rome Congress it was agreed that suitable advertisements should be accepted in the publication in order to augment the revenue from its sales and by this means the publishers are confident that they can make a substantial increase in its size. Already the flow of contributed articles has greatly exceeded expectations and there is an accumulation of material awaiting publication, as a result.

An inevitable difficulty in the publication of an international journal arises from the need to include material written in several different languages. Up to the present time, the papers published in the *Acta* have included more or less equal numbers in German and English, each paper being accompanied by an abstract in English, French and German. Uniformity in the selection of material for publication is difficult in such circumstances, since papers in each particular language are considered by the editors speaking that language. A system such as that adopted in the *B.I.S. Journal* whereby every paper has to be read by each member of an editorial board has not yet proved possible in the case of the *Acta*.

The publication in a journal of articles in two or three different languages also leads to sales difficulties, particularly with respect to the private subscriber, who, unless he is proficient at languages, can derive no benefit from much of the text. This situation undoubtedly has had repercussians on the circulation of the *Acta* and, in the circumstances, the results that have been achieved to date are regarded as fairly satisfactory.

The language difficulties are bound to increase as the I.A.F. becomes more genuinely international. An influx of papers in the Russian language, which is quite likely and desirable, in view of the fact that the U.S.S.R. is now

represented in the I.A.F., would, for example, pose serious editorial difficulties. Ultimately the only solution to the language problem would be to publish several versions of the *Acta* each in one particular language. The cost and effort involved in such a procedure would prove to be prohibitive at present and it must remain a dream which might be realized at some future time.

The International Astronautical Congresses

The congresses of the I.A.F. have been established as annual events. They have taken place successively at Paris (1950), London (1951), Stuttgart (1952), Zurich (1953), Innsbruck (1954), Copenhagen (1955) and Rome (1956). The 1957 Congress will take place at Barcelona in October and it is planned that the 1958 Congress should be held in the Netherlands. In each case the member-society in the country where the Congress is held has had the responsibility for organizing the event. Generally speaking some support has been obtained from civic authorities, governmental agencies or from universities.

A fairly standard recipe has been followed in the congresses, the main ingredients being: the business meetings of the I.A.F. Council, the technical symposia, film shows and, not least, the social functions.

This pattern is not unique, of course: technical symposia and social events are common to most international meetings of scientific societies and other learned bodies. The relatively large amount of time devoted to I.A.F. council meetings is, perhaps, one respect in which these congresses differ from other scientific conferences. This is a consequence of the fact that, in the past, the I.A.F. Council has had no opportunity of meeting outside the congress periods. Since the business meetings encroach to a great extent upon the time available for the technical symposia, one might hope that, in the future, meetings of the Council and committees might take place in the interval between congresses. A precedent for this has been set this year by the recent meeting of the International Affairs Committee which was convened by its Chairman, Mr. Haley, in Paris, on April 15 and 16. It is possible that such meetings might become a normal practice in the future and that, as a result, it might be possible to concentrate mainly upon the technical symposia during the annual congresses.

The first I.A.F. technical symposium took place at the London Congress and it was based upon a theme: "The Artificial Satellite". At that time astronautics, as distinct from military rocket development, was still primarily an amateur field and the papers were contributed more or less entirely by individuals having a considerable scientific interest in the subject without being engaged professionally in its pursuit. With the emergence of actual satellite projects this pattern is changing and it must be anticipated that future I.A.F. symposia will be gradually "taken over" to a large extent by people whose professional occupation is concerned with the development of astronautics. This is a state of affairs which is highly desirable, of course, though it must always be necessary to encourage contributions from independent scientists and authorities, in relevant fields, who can bring forward new ideas. In any case, the range of natural and social sciences and technologies that are in some way relevant to spaceflight, is so wide, that it would be difficult, if not impossible, to define a clear-cut profession of astronautics.

Recently, in order to encourage individual contributions to astronautics, the I.A.F. Council has instituted an award, the Guenter Loeser Memorial Medal. This is given to the author of the paper, presented at a Congress symposium, which is judged to be the most significant and original contribution to that particular symposium. The medal commemorates Dr. Guenter Loeser, one of the founders of the I.A.F., who was killed in 1953, in a helicopter accident in the U.S.A. The first recipient of the award was Krafft Ehricke, whose paper on the "Satelloid" was considered to be the most important presented at the Copenhagen Congress.

Not the least important aspect of the I.A.F. Congresses is the fact that they serve to bring together individuals from all parts of the world who are interested in the development of astronautics. It is the promotion of fellowship between the people of all nations who are concerned with this common objective that is the basic purpose of the International Astronautical Federation and the Annual Congresses are the main instrument for achieving this purpose.

Member Societies of the I.A.F.

The membership of the I.A.F. during the current year consists of the following societies:—

Agrupacion Astronautica Espanola.
American Rocket Society.
American Astronautical Society.
Asociacion Argentina Interplanetaria.
Association Egyptienne Astronautique.
Associazione Italiana Razzi.
Astronauticko Drustvo (Jugoslavia).
British Interplanetary Society.
Commission on Astronautics, U.S.S.R. Academy of Sciences.
Dansk Interplanetarisk Selskab.
Deutsche Arbeitsgemeinschaft für Rakententechink.
Deutsches Raketen und Raumfahrt Museum e.V.
Gesellschaft für Weltraumforschung.
Japanese Astronautical Society.
Nederlandse Vereniging voor Ruimtevaart.
Norsk Astronautisk Forening.
Oesterreichische Gesellschaft für Weltraumforschung.
Polski Towarzystwo Astronauticzne.
Schweizerische Astronautische Arbeitsgemeinschaft.
Sociedate Interplanetaria Brasileira.
Sociedad Interplanetaria Chilena.
Société Française d'Astronautique.
South African Interplanetary Society.
Svensk Interplanetarisk Selskap.
University of Cuyo (Institution Member).

Building the Earth Satellite Vehicle

1. Basic structure of the Satellite consists of two hemispheres and certain other structural parts, chiefly inside the sphere. First operation in making the hemisphere is to deep draw a circular Magnesium blank which is 0·091 in. thick. The material is AZ-31B alloy consisting of 96 per cent. Magnesium, 3 per cent. aluminium, and 1 per cent. zinc. For this drawing operation, done with one die in one stroke of the press, the material is heated to 650° F. The lubricant is colliodal graphite. The die consists of a cast-iron punch, and upper and lower draw rings

By courtesy of Brooks & Perkins, Inc.

2. Flash is trimmed off the drawn hemisphere and it is placed over a hemisphere spin block (also cast iron), heated by acetylene torch to about 600° F., and spun to exact dimensions required. Spinning is one of the few metalworking operations which could be called an art. Successful spinning depends largely upon the skill of the operator and his ability to sense the feel of the movement of the metal as it is spun to shape. He varies the pressure applied as the metal is spun to shape

By courtesy of Brooks & Perkins, Inc.

3. An inner ring which will form a pressure-tight circular chamber in the finished hemisphere is then spun from a flat circular blank of Magnesium. Here the operator spins this blank over a spin block

By courtesy of Brooks & Perkins, Inc.

4. The depressed contoured portion of the spinning is trimmed out of the spinning; two fittings are welded in; and it is now welded into the proper location in the interior of the Satellite hemisphere

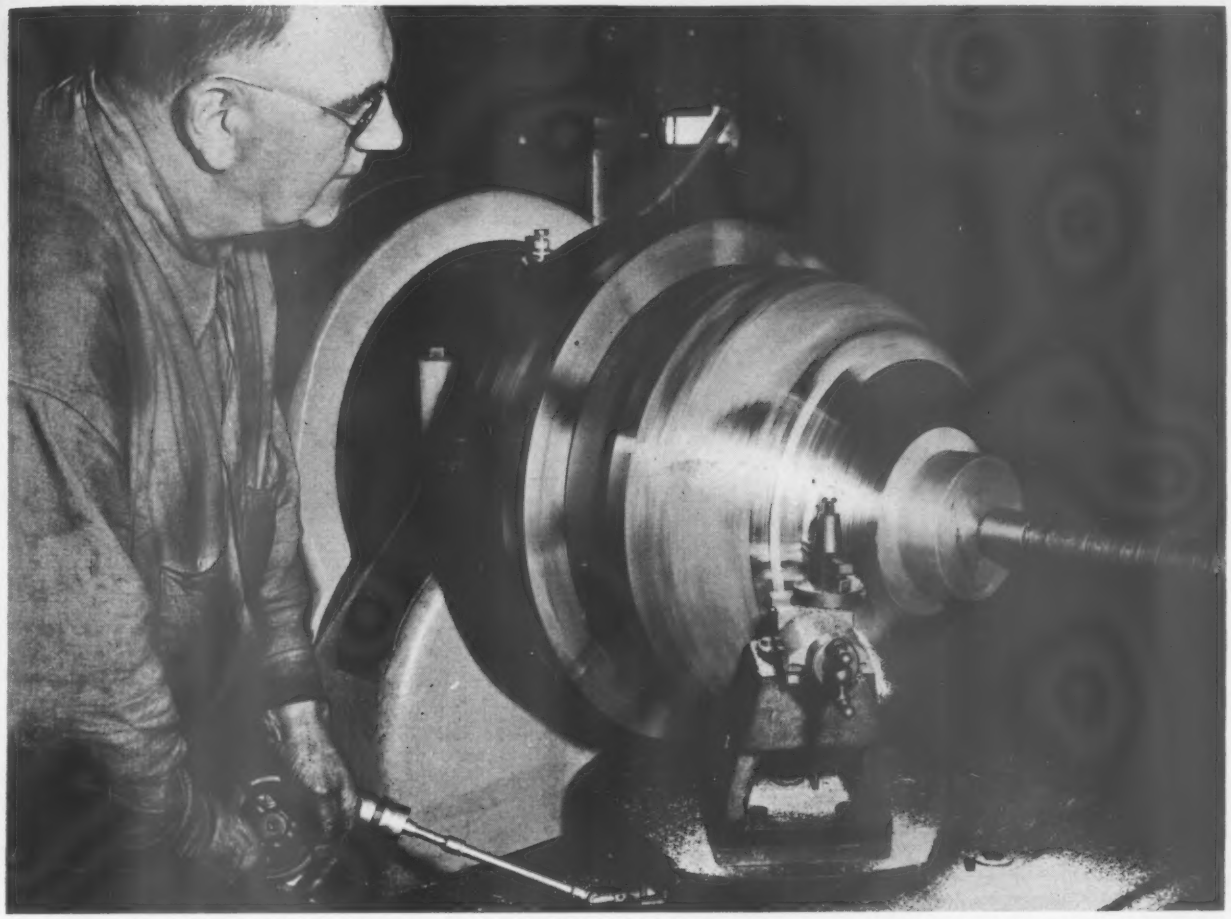
By courtesy of Brooks & Perkins, Inc.

5. A cross-section view shows the resulting pressure cavity

By courtesy of Brooks & Perkins, Inc.

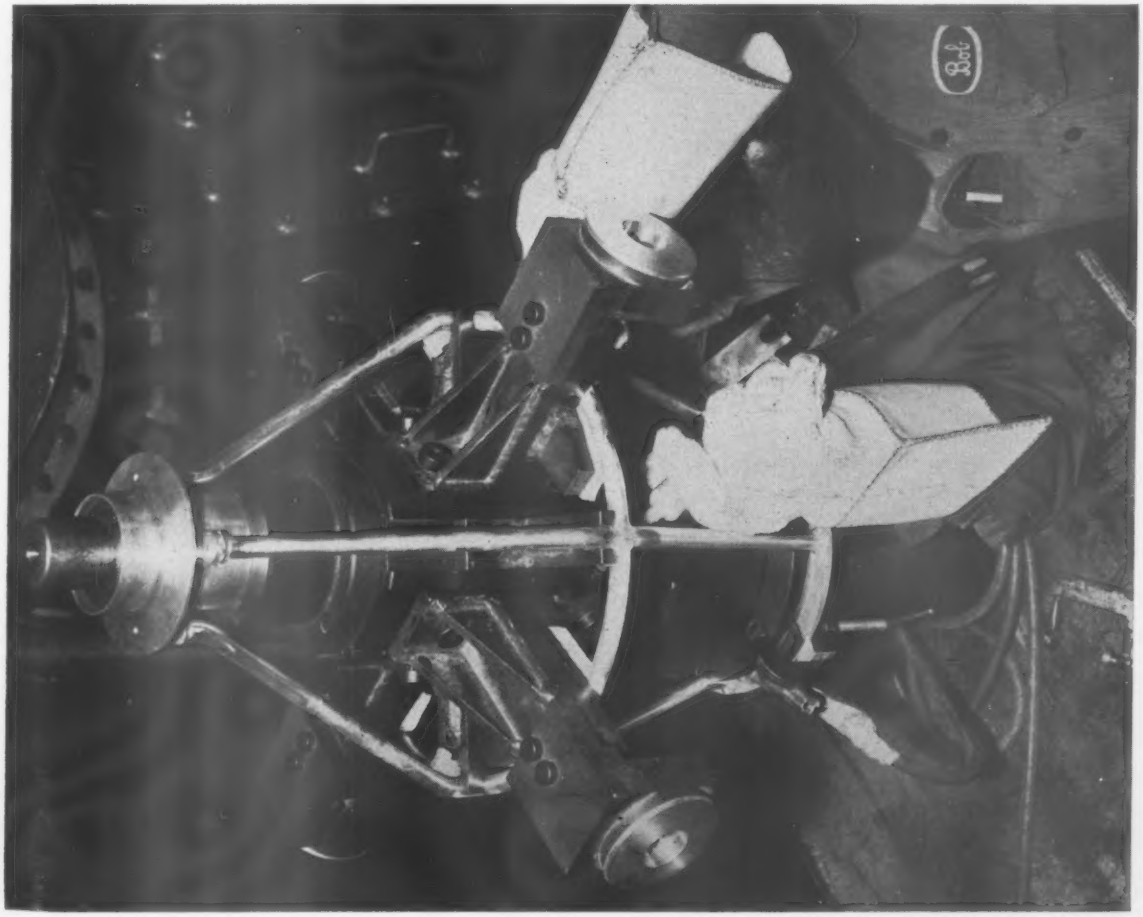
6. After welding, the hemisphere is placed in an oven and heated briefly to relieve any stresses which may have been set up by welding, so there will be no future possibilities of weld cracks

By courtesy of Brooks & Perkins, Inc.



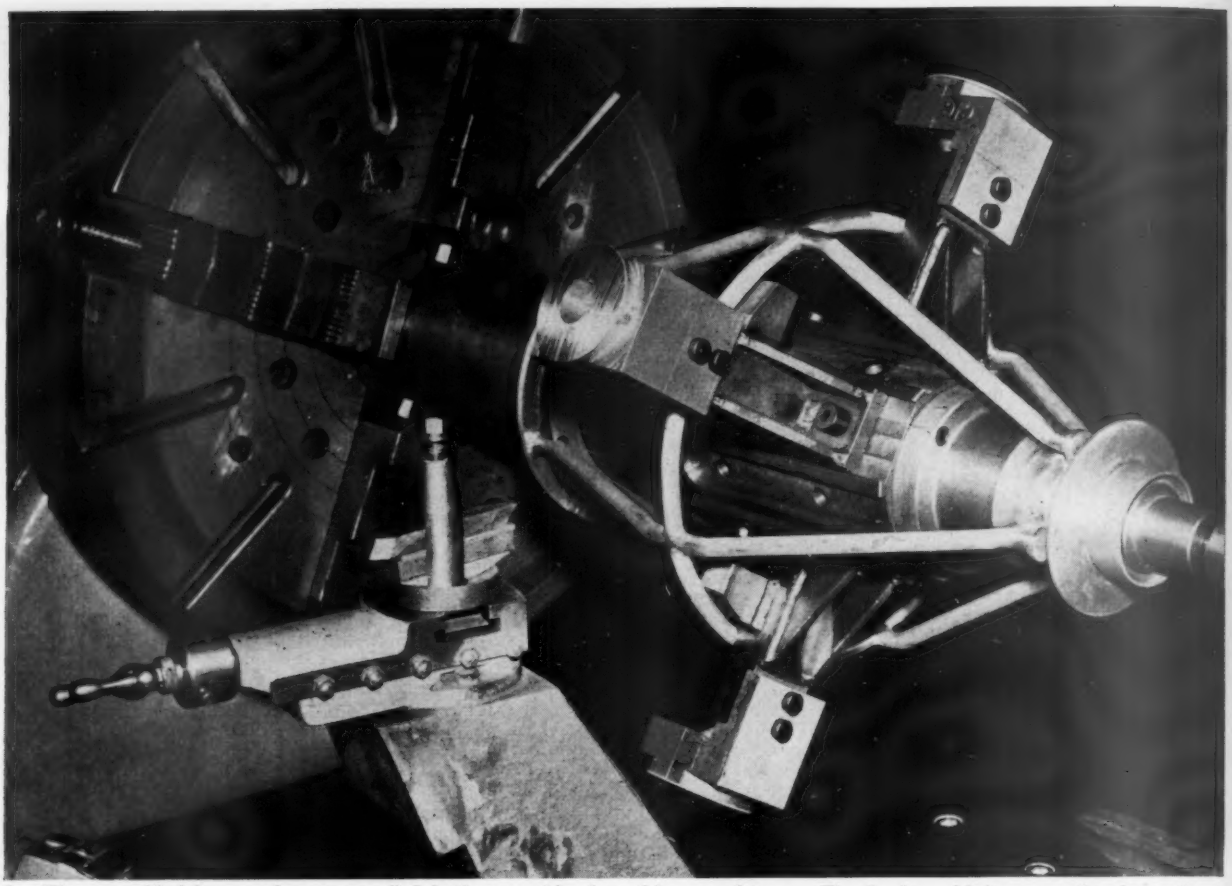
7. The pressure-tightness of the weld is tested, then the hemisphere is placed over a very exact cast-iron machining block and the entire skin machined to finish thickness. Most of the surface must be 0·028 in. thick. No distortion due to welding or machining is permitted

By courtesy of Brooks & Perkins, Inc.



8. The internal structure frame is chiefly Magnesium tubing, although certain parts such as antenna mounts are machined from solid Magnesium bar. The frame is assembled and welded on this fixture

By courtesy of Brooks & Perkins, Inc.



9. The assembled frame, after stress relief, is then machined on this same fixture. The final machining operation is on those surfaces which will be at the surface of the sheet metal Satellite sphere

By courtesy of Brooks & Perkins, Inc.

10. The hemispheres and frame, together with any other parts, are then buffed to high mirror-like polish. Here we see a polishing operation on the interior of one of the hemispheres. It is difficult to get a true view of this because everything within range is reflected in the mirror-like surface

By courtesy of Brooks & Perkins Inc.

11. All parts of the Satellite are now plated at B. & P's Livonia plant. They are given a copper flash, copper plating, silver plating, then gold plating. They are re-polished between each plating operation. Naval Research Laboratory will later have added to the outside of the Satellite vaporized chromium, a glass-like transparent silicon monoxide coating, a microscopically thin film of vaporized aluminium, and finally another coating of silicon monoxide

By courtesy of Brooks & Perkins, Inc.

12. J. S. Kirkpatrick, B. & P's Vice-President—Research and Development—shows the Satellite partially assembled. Final assembly is by using hundreds of very small jeweller-type screws. Thin channels formed from sheet Magnesium and curved are used inside the hemispheres to join the edges of the two hemispheres and the internal frame. The finished Satellite has a high degree of reflectivity; its surface is a perfect mirror. The Satellite is subsequently sprayed with a strippable plastic coating to protect its surface and then packed in a fish net, suspended from all sides of its wooden container box, to prevent any damage during shipment and handling

By courtesy of Brooks & Perkins, Inc.

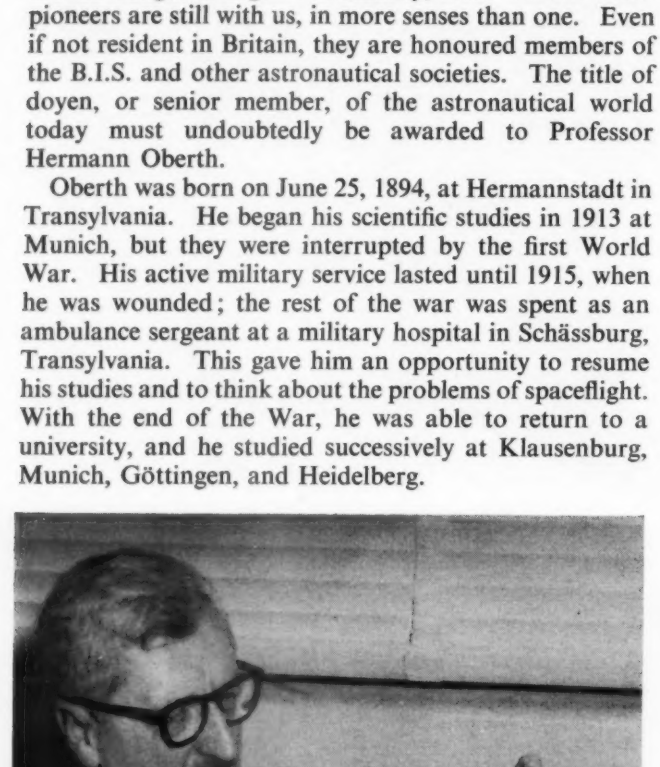
OBERTH—Doyen of Spaceflight Today

By G. V. E. THOMPSON, B.SC., A.R.C.S., F.R.I.C., A.I.L., L.I.M.

The life and work of the man who is justly known as the "Father of Astronautics"

The previous articles in this historical and biographical series have all dealt with pioneers of astronautics who are no longer living. Fortunately, some of the other pioneers are still with us, in more senses than one. Even if not resident in Britain, they are honoured members of the B.I.S. and other astronautical societies. The title of doyen, or senior member, of the astronautical world today must undoubtedly be awarded to Professor Hermann Oberth.

Oberth was born on June 25, 1894, at Hermannstadt in Transylvania. He began his scientific studies in 1913 at Munich, but they were interrupted by the first World War. His active military service lasted until 1915, when he was wounded; the rest of the war was spent as an ambulance sergeant at a military hospital in Schässburg, Transylvania. This gave him an opportunity to resume his studies and to think about the problems of spaceflight. With the end of the War, he was able to return to a university, and he studied successively at Klausenburg, Munich, Göttingen, and Heidelberg.



PROFESSOR HERMANN OBERTH

It was now 1923, and in that year he published a small book entitled *Die Rakete zu den Planetenräumen* (The Rocket into Interplanetary Space). The firm who issued the book, R. Oldenbourg of Munich, were not very enthusiastic about it, but the first edition sold out rapidly, as did a reprint. This was largely due to popular interest, but professional scientists and engineers also read—and criticized—the book. Much of the criticism was based on erroneous facts or fallacious arguments, but the same arguments against space travel were still being used 25 years later, and indeed are sometimes met with today. However, many people were convinced by Oberth's work and other books on the subject began to appear.

Meanwhile Oberth had become a teacher at Schässburg, where he remained until 1926, when he became Professor of Mathematics at Mediash, another town in Transylvania. But his departure for Roumania, was no sign that the ideas he had put forward in his book had been rejected. More and more people became enthusiastic about his proposals, and soon a society had been founded in Germany to spread these ideas and encourage further work on the subject. This society was named the Verein für Raumschiffahrt, or Society for Space Travel, and Oberth was one of its first members. Within a year the membership was about 500.

He was not away from Germany for long. In 1928 he obtained leave of absence from his work and went to Berlin. This visit was occasioned by the production of a film entitled *Frau im Mond* (The Girl in the Moon) by the UFA Film Company. It was to be made by the great Fritz Lang, and while by no means the first film to deal with space travel, some attempt appears to have been made to make it scientifically accurate. Oberth was to act as technical adviser.

So far, so good ! The film was eventually produced, but in the early stages of the production it was also arranged the company should finance some rocket research to be carried out by Prof. Oberth, Willy Ley and their assistants. This was something to be glad about, for it offered a chance of making some real practical progress. But there was one important snag in the arrangements. The money to be provided was supposed to come out of the advertising budget for the film, and some return on this outlay was to be obtained by firing a full-scale Oberth rocket on the day of the film première. No doubt, if this had been possible it would have given considerable publicity to the film (and also to astronautics), but both the money and time available were insufficient for the project to be carried through successfully.

Even today with all the resources of Governments available, making a film is an easier task than developing a guided missile. Oberth had to design and develop a workable rocket entirely "from scratch" within a matter of a few months; the project was doomed from the start. Nevertheless, he had at least started experiments with liquid-propellent rockets in Germany. The propellants used were liquid air or oxygen and petrol; one or two or two explosions occurred, and in one of these Oberth was lucky to escape serious injury.

When it became apparent that the rocket would not be available for publicity purposes, the film company withdrew their support, such as it was. After the première, Oberth returned to Mediash, but he was back again in Berlin the following year to continue his experiments, in conjunction with the VfR. The additional time enabled him to achieve some success, and the Chemisch-Technische Reichsanstalt (an organization roughly equivalent to our National Physical Laboratory, or the U.S. National Bureau of Standards) certified that on July 23, 1930, the Kegeldüse, as Oberth called his rocket, had developed a constant thrust of about 7 kilogrammes over a period of 90 seconds, consuming 6 kilogrammes of liquid oxygen and one kilogramme of petrol. His experiments could not continue for long, however, as he was naturally required back at Mediash.

He had also achieved recognition in another way. His book was extensively revised and enlarged for the third edition, which was published in Munich in 1929 under a a new title, *Wege zur Raumschffahrt* (Road to Space Travel), and it won for him the first award of the REP-Hirsch Prize. This was intended to be an annual award for work in the field of astronautics; it had a value of 5,000 francs and was established by the Parisian banker André Hirsch and another astronautical pioneer, Robert Esnault-Pelterie. Actually, *Wege zur Raumschiffahrt* was intended to be but the first of two volumes, but the second was never finished.

In 1938, he left Mediash for Vienna, having been appointed a professor at the Technische Hochschule, under a contract from the Luftwaffe. During the intervening years, he had done little experimental work on rockets, but had continued with his theoretical studies. Much had been happening in Germany itself. The Nazis had come to power, the army had become interested in liquid-propellent rockets, and research establishments to develop them had been established first at Kummersdorf, and then at Peenemünde. Professor Oberth probably gained his appointment because of inter-service rivalry between the Luftwaffe and the army, although the advantage of Germany getting hold of him before any other great power could do so was no doubt also in the minds of those who awarded him the contract. Whatever the reason, when he arrived at Vienna the facilities and assistance given him were utterly inadequate for someone of his calibre or for the task he had been set. He remained there for about two years.

At the end of that period a general policy decision of the Nazi government made the army entirely responsible for ground-to-ground rocket missiles, and one of the consequences of this decision was that Oberth was now working for the army. They transferred him to the Technische Hochschule at Dresden, to work on the development of a fuel-pump for a large rocket. This might seem a rather peculiar problem for him to be asked to tackle, but he had himself stressed the importance of propellent pumps for liquid-propellent rockets. What *was* peculiar perhaps was that although he did not know it at the time, the pump was intended for the A-4 (or V-2) rocket, a project which had already passed the design and development stages and was about to go into production, He was working on something which had already been satisfactorily completed.

However, his Dresden post was something of a stop-gap until he acquired German citizenship. He was then a Roumanian citizen, although of Saxon descent, and the authorities told him bluntly that he could not leave Germany again; it was German citizenship or a concentration camp.

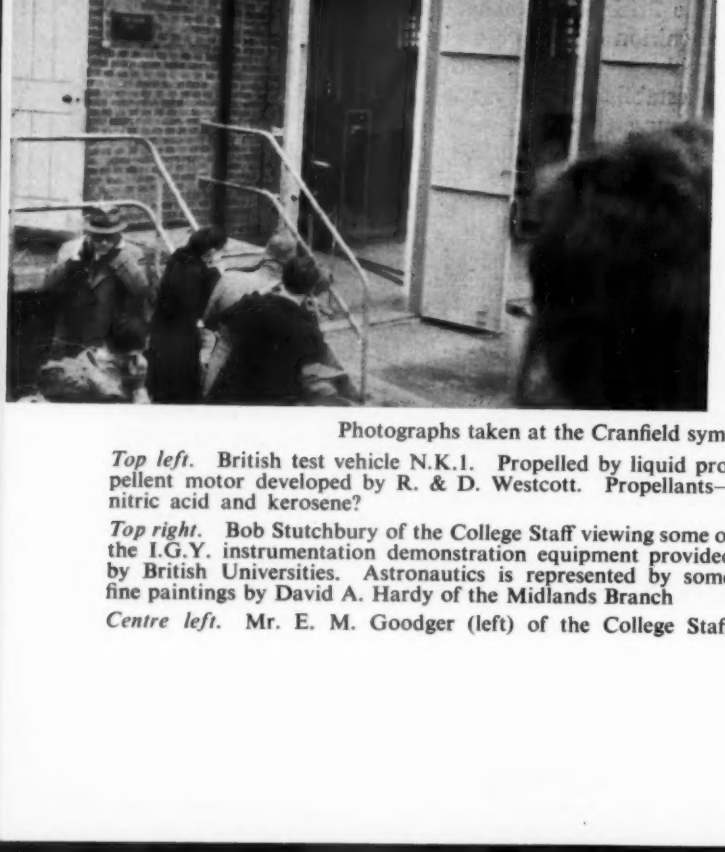
As soon as he had obtained his citizenship, he was transferred to the big rocket establishment at Peenemünde, where he found that progress had been more rapid than he could have thought possible. Since the design of V-2 was completed he could not work on that, but he tackled various other projects. Eventually he submitted a proposal for a solid-fuel anti-aircraft rocket, which was considered promising enough to go into development at the WASAG plant, Reinsdorf (Peenemünde dealt only with liquid-propellent rockets). Oberth went to Reinsdorf in 1943 for this purpose, but his work there was interrupted by the end of the War.

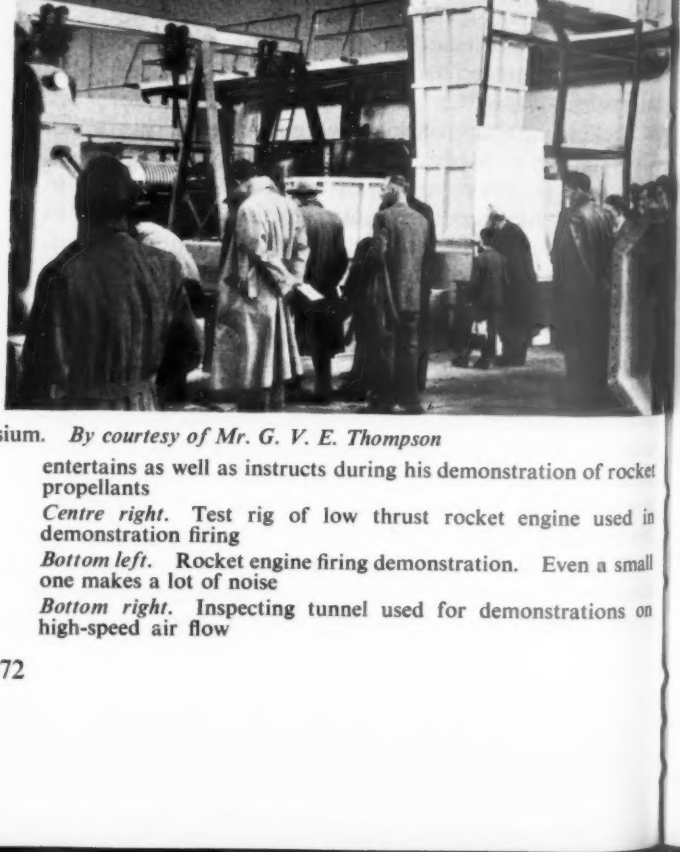
With the occupation of Germany, he was detained for four months in a camp called "Dustbin", but was later released. He lived for some time at Feucht, near Nuremburg, where he had purchased a house and some land, in 1943 but later he went to live in Italy.

In 1943 Prof. Oberth became the first Honorary Fellow of the British Interplanetary Society, an award made in recognition of his great pioneering activities in the field of rocket research. Another recognition of his work was the establishment by the Gesellschaft für Weltraumforschung (the post-war successor of the VfR) of a Hermann Oberth medal, to be awarded for distinguished contributions to astronautics.

Prof. Oberth has not finished his work for astronautics and rocketry. Since 1955 he has been working in America, and has written a new book, to be published later this year.

His outstanding achievement in astronautics thus far has undoubtedly been his previous book. While he was preceded by Tsiolkovskii and Goddard, both great pioneers in this field, Oberth made many original contributions, and was directly responsible for the surge of interest that led to the development of the V-2. The importance of his book is illustrated by the fact that it was one of the German volumes chosen by the U.S. Government for reprinting during the Second World War, when such volumes were unobtainable in the Allied countries.





Photographs taken at the Cranfield symposium. *By courtesy of Mr. G. V. E. Thompson*

Top left. British test vehicle N.K.1. Propelled by liquid propellent motor developed by R. & D. Westcott. Propellants—nitric acid and kerosene?

Top right. Bob Stutchbury of the College Staff viewing some of the I.G.Y. instrumentation demonstration equipment provided by British Universities. Astronautics is represented by some fine paintings by David A. Hardy of the Midlands Branch

Centre left. Mr. E. M. Goodger (left) of the College Staff entertains as well as instructs during his demonstration of rocket propellants

Centre right. Test rig of low thrust rocket engine used in demonstration firing

Bottom left. Rocket engine firing demonstration. Even a small one makes a lot of noise

Bottom right. Inspecting tunnel used for demonstrations on high-speed air flow

The Cranfield Symposium

By S. W. GREENWOOD

It was a typical English summer day, starting with a cloudy sky and the thoughts of light showers, and developing into a warm sunny afternoon. B.I.S. members and their friends, visitors from the nearby towns and villages, R.A.F. cadets from Halton, members of the College staff and may others moved among the exhibits on high altitude and satellite rockets that followed the symposium on this subject held on July 18-20, 1957, at the College of Aeronautics at Cranfield in Bedfordshire.

Exhibits included the British Skylark rocket vehicle, a sectioned Veronique from France, examples of current British rocket engine practice, demonstrations of instrumentation for upper atmosphere research by members of the staff of University College, London, and the University of Birmingham, paintings of astronautical themes by David A. Hardy, and demonstrations of supersonic wind tunnels, rocket propellant combustion and a rocket engine firing.

The symposium had proved an enjoyable and memorable occasion. Organized jointly by the Royal Aeronautical Society, the British Interplanetary Society and the College of Aeronautics, it had served to bring together these three bodies in a co-operative activity connected with the use of rocket vehicles in the I.G.Y. and beyond. The first proposal for a symposium of this type at the College was made by T. R. F. Nonweiler about 18 months ago, as a B.I.S.-College venture. The Royal Aeronautical Society was invited to become one of the organizers when that society expressed interest in the symposium. Professor A. D. Baxter, of the College, one of the leading fellows of the B.I.S. and a member of the Council of the Royal Aeronautical Society, became Chairman of the organizing Committee. D. S. Carton, together with the author of this article, were considerably helped by the various bodies supplying material in organizing the Exhibition.

An informal reception was held on the evening of July 7 in the lounge of the Stafford Cripps building. Most of the 180 people attending the symposium were present. It was a cheerful occasion, marked by the pleasure of old friends meeting, of putting faces to names and names to faces, and the consumption of stimulating refreshment.

The symposium was formally opened on the following morning by Professor A. J. Murphy, Principal of the College. He welcomed the members, and said that it was the first symposium of its kind in Britain.

A full list of the proceedings is given below, together with a brief summary of the papers. Discussions were lively and informative, but space limitations prevent their being reported here. In due course, Proceedings, with full discussions and replies, will be published and available for purchase by all who are interested.

July 17
Evening

Informal reception.

July 18
Morning

Opening remarks by the Chairman, Professor A. J. Murphy (Principal, College of Aeronautics).

The Scientific Applications of Rockets and Satellites, by H. S. W. Massey, F.R.S. (University College, London).

Rockets are essential for some high altitude research studies, particularly for work on solar radiation. Research with rockets has become experimental as well as observational, an example of the former being the study of the effects of solar radiation on sodium vapour discharged into the atmosphere from the rocket. Satellite rockets are needed for the study of the variation of phenomena with time and latitude.

Skylark No. 4 with the tail end of a V2 in the background
By courtesy of the Bedfordshire Times Publishing Co. Ltd.

The Satellite Launching Vehicle, by Milton W. Rosen (Naval Research Laboratory, Washington, D.C.).

The Vanguard vehicle and the satellite were described. To minimize the guidance precision requirements, a substantial excess final velocity capability has been maintained. Six satellite attempts will be made, and the objective will be accomplished when one of these is successful.

British Upper Atmosphere Sounding Rocket, by W. H. Stephens (Royal Aircraft Establishment).

The Skylark vehicle and its motor were described. Skylark is designed to carry payloads of 100–150 lb. to a height of 95 miles. To increase altitude performance, several changes in design are planned. With a small separating boost motor, the maximum height should be raised to 130 miles.

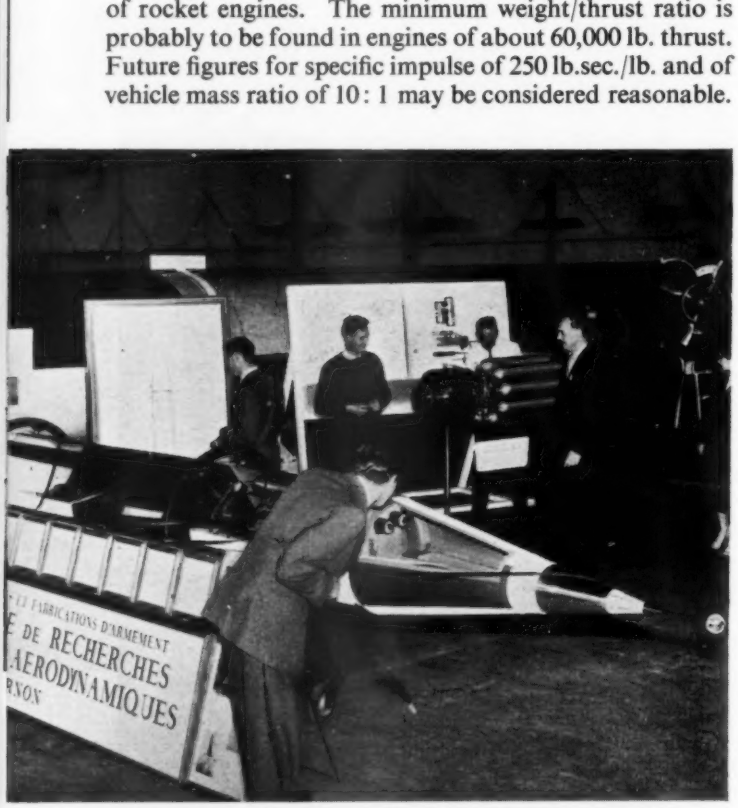
Afternoon

Chairman: Dr. L. R. Shepherd (President, International Astronautical Federation).

Professor B. M. Petrov, one of the four Russian members of the symposium, opened the proceedings with a message of greeting on behalf of the Russian Academy of Sciences.

Some Propulsion Problems of High Altitude Rockets, by Professor A. D. Baxter (Head of Department of Aircraft Propulsion and Vice-Principal, College of Aeronautics).

A number of factors affect the performance and weight of rocket engines. The minimum weight/thrust ratio is probably to be found in engines of about 60,000 lb. thrust. Future figures for specific impulse of 250 lb.sec./lb. and of vehicle mass ratio of 10: 1 may be considered reasonable.



The superb sectioned Veronique and a De Havilland Super Sprite
By courtesy of the Bedfordshire Times Publishing Co. Ltd.

Design Problems of Large Rockets, by K. J. Bossart (Convair-Astronautics).

A suggested basis for attempting to determine the design features of large rockets by principles of scaling-up from experience on the design of small rockets is given. For fully similar vehicles cross-sectional area is proportional to length^2 whereas thrust is proportional to length^3. For large vehicles this tends to cause an increase in structure weight from stressing considerations, and hence a departure from true similarity. On the other hand, aerodynamic heating is a less severe problem with large vehicles. Additional factors to be considered are vehicle stability and control, effect of size on optimum flight path, and problems of handling. The ultimate permissible size will be determined by considerations of operating economy and by the size of man and his tools.

Evening

Film show: a varied programme of short films on instrumentation and vehicles for upper atmosphere research was presented.

July 19

Morning

Chairman: Mr. G. W. H. Gardner (Director, Royal Aircraft Establishment).

Before the formal proceedings began, Professor B. M. Petrov made a statement on the Russian rocket and earth satellite programme for the I.G.Y. The firing of the rockets and the satellites will be conducted approximately at evenly-spaced intervals throughout the I.G.Y. Satellite launchings will be made from Russia at a small angle to the meridian, and the satellites will consequently be observable in all the areas of the Earth except the central areas of the Arctic and the Antarctic.

Re-entry and Recovery, by W. F. Hilton (Chief Aerodynamicist, Sir W. G. Armstrong Whitworth Aircraft Co.).

A suggested vehicle design is given in which, under re-entry conditions, the pilot's cabin and one entire surface of the vehicle are protected from extreme heating effects by being placed in an aerodynamic vacuum. The scheme is also based on the principle of producing maximum drag associated with maximum lift during re-entry (the "lift" being in the downwards direction in the early stages of re-entry). The author concludes that the use of an aerodynamic vacuum to protect vital cargo is both novel and essential to successful re-entry from any altitude above a few hundred miles.

Dynamics of a Dissociating Gas Non-Equilibrium Theory, by N. C. Freeman (Aerodynamics Division, National Physical Laboratory).

A rather specialized treatment is presented of the effects of progressively changing composition of the gas in the region behind the shock wave formed ahead of a bluff body at high speeds. The greater the degree of dissociation, the closer the wave lies to the body.

High Temperature Materials in relation to the Satellite Re-entry Problem, by P. Murray (Atomic Energy Research Establishment, Harwell).

It is considered necessary that the vehicle shell should be metallic, and it must therefore be protected by a layer of insulating material. Abrasion of the insulating material by the high-speed air flows necessitates covering it with an expendable metallic surface, or developing a method of fusing the insulation to produce a tougher surface.

Afternoon

Chairman: Sir Geroge Edwards (President, Royal Aeronautical Society).

Some Problems of Instrumentation, Telemetry and Guidance, by A. W. Lines (Guided Weapons Department, Royal Aircraft Establishment).

Significant improvements have been made in the operating ranges and ability to withstand vibration of some standard high altitude instrumentation. The telemetry system for the Skylark uses the well-known equipment operating at a frequency of 465 Megacycles/sec., with frequency modulation. The problem of accurate placing of a satellite vehicle into a desired orbit is one of great difficulty. On the grounds of economy in payload, consideration is given to a radar-radio guidance system.

Problems of Respiratory Metabolism in Sealed Cabins, by Hans G. Clamman (School of Aviation Medicine, U.S. Air Force).

A sealed cabin is defined as one which carries all oxygen needed and, in addition, means to remove all waste gases, thus maintaining suitable environmental conditions. The concept of a sealed cabin precludes the discharge of waste from the cabin. Regenerative and recirculation processes have to be developed. Chemical systems are limited to short duration journeys measured in days or weeks. For longer periods, the use of plants such as algæ as gas exchangers appears attractive, but the achievement of a balanced system is hard to obtain.

Psycho-Physiological Hazards of Satellite Flight, by Lt.-Col. J. P. Henry (European Office, U.S. Air Force Research and Development Command).

Experiments on individual animals and humans have indicated that mental disturbances follow being severely deprived of sensory inflow to the brain for a few days. There is need for more research in this field. The human operator's task should be designed to provide him with meaningful and stimulating activity.

Evening

Symposium Dinner: The dinner was held in Mitchell Hall, at the College, and the conversation, mainly on the theme of the symposium, was spirited. Responders to the toast "The Guests", proposed by the Principal of the College, were Air Chief Marshal Sir Philip Joubert de la Ferté, Sir George Edwards and Mr. K. J. Bossart.

July 20

Morning

Chairman: Professor A. D. Baxter (Head of Department of Aircraft Propulsion and Vice-Principal, College of Aeronautics. Deputizing for Mr. R. A. Smith, Chairman, British Interplanetary Society, who was unable to be present).

Future Developments in Rocket Propulsion beyond the Atmosphere, by L. R. Shepherd (Atomic Energy Research Establishment, Harwell).

Further developments of the rocket will permit transporting larger payloads than that of the Vanguard into close orbits around the Earth. The re-entry problem appears soluble, although a manned re-entry vehicle might be relatively massive, and the take-off vehicle might be required to have an all-up weight of several hundred tons. The successful development of a nuclear-powered rocket could make it possible to transport men to and from the Moon. Such a rocket would probably use a nuclear reaction to heat up a working fluid which was then expanded through a nozzle.

* * * *

Nearly all the members of the symposium were sponsored by the organizations to which they belonged. These included many branches of industry and the research and teaching fields. It seemed that everyone was agreed that the occasion had been of value in stimulating thought and discussion, and that the three organizing bodies would derive benefit from the venture.

Talking things over. Mr. Milton W. Rosen (*left*) and Professor A. J. Murphy

By courtesy of the Bedfordshire Times Publishing Co. Ltd.

America's Surface-to-Surface Missile Arsenal

By FREDERICK I. ORDWAY, III, B.S. and RONALD C. WAKEFORD, A.F.R.Ae.S.

To say that the surface-to-surface missile is a product of our times is to commit a serious error: the history and evolution of this weapon has its roots deep in the past. As early as the eleventh century the Chinese utilized black powder rockets ("fire arrows"), which probably represented the S.S.M. in its most primitive form.

In any historical sketch many other examples of the ancestry of the mid twentieth century ballistic missile can be given. We can go back to William Congreve, whose notable achievements fathered later European development of the weapon, and whose rocket projectiles were used effectively at Copenhagen (1805) by the Royal Navy, and again in the Battle of Leipzig (1813) by the British Army.

It was left to the Germans, however, to pave the hesitatingly begun road which led on to modern ballistic and air-breathing surface-to-surface missiles. Rocket experimentation, begun in theoretical application as early as 1920, had, by the 30's, advanced into the hardware stage. Two main lines of development followed, one leading into the V1 air-breathing jet programme and the other resulting in the ballistic V2 rocket programme. Both these missiles formed the basis for post-war American S.S.M. developments, one line resulting in Matadors and Regulus', the other in Corporals, Redstones and the like.

World War II Germany also produced the significant A9/A10 multi-stage long-range missile concept. Perusal of the design information and performance estimates show that it would now be called an ICBM: it was within the calculated capability of this weapon to destroy targets on the East Coast of the United States. This vehicle, too, inspired IRBM and ICBM research in North America.

The A9/A10 was to have been a two-step vehicle, the second stage being a modified delta wing V2, the first an 87 ton A10 booster. It was estimated that it would reach a top speed of 6,000 m.p.h. Here is a vehicle concept hatched during the war years in Europe, which, nearly 15 years later, is just coming to fruition in the United States.

Developments

Since the war, great progress has been made in the United States with ballistic missiles and the recent months have provided much spectacular news. Old records have been shattered by a three-stage missile (mating small modified Sargeant rockets to the large Redstone), which flew 3,300 miles out over the Atlantic. A 650 mile altitude record and a top speed of 15,000 m.p.h. have been widely reported for this spectacular flight,

F. I. ORDWAY

which was designed to check out guidance, telemetering, tracking, and separation techniques. A new plateau in rocketry had been reached. Both Thor and Jupiter missiles are now in the preliminary flight test stage, and so far Thor has been a complete failure, while Jupiter aborted its first two firings, but was very successful in its last two. Atlas made one unsuccessful flight attempt.

When it is considered that during the war years, the bazooka and a variety of rocket barrage weapons (with ranges measured in yards) were the major contributions of the United States, the tremendous progress recorded can be appreciated. Many inherent and difficult problems associated with ballistic missiles have been overcome. Instrumentation has been successfully transistorized and miniaturized, and highly accurate guidance techniques utilizing natural phenomena, as well as mechanical methods, have been developed. Continual wind tunnel and material testing have brought one of the greatest problems, aerodynamic heating, under a steady barrage of scientific study, and solutions are providing scientists and engineers with new hopes for greater things.

FIG. 1. An artist's impression of the Regulus II, as it is launched from a submarine (Official U.S. Navy photograph)

It is undoubtedly true that many of the important recent scientific advancements would not have been made without enormous U.S. government support for guided missile research and design (see table). In 12 post-war years the rate of scientific advancement has become necessarily accelerated by the fear of war, and progress, oddly enough, seems to be the product of such fear. This is a melancholy situation within which we must live; yet it is one we philosophically accept, knowing that the ICBM represents a crucial milestone towards the realization of space travel. As Ballistic Missile Division Chief, General Shriever has pointed out, 90 per cent. of IRBM-ICBM research is directly applicable to space flight. The Air Force has let it become known that it is currently planning a lunar programme.

The primary purpose of ballistic missiles is a matter of some controversy between the three American armed services, the greatest areas of disagreement being between the Army and the Air Force. The Army sees the ballistic missile as merely an extension of long-range artillery, while the Air Force contends that it is nothing more than a long-range unmanned bomber. Separate research and development programmes have been set up by both services, and many authorities feel that there is much duplication of effort and unnecessary expenditure of available defence funds.

Much has been made of the current missile dispute between the Army and the Air Force. The Army's Jupiter has proved to have been, so far at least, the superior weapon, and the Department of Defence has allocated funds for its continuing development during most of 1957. At the end of the year a decision was expected to be made as to whether or not the Army would continue with Jupiter, whether the Air Force would take over its support, or whether it might possibly be dropped altogether. It was also considered that the Thor project of the Air Force might be cancelled instead. Earlier this summer General Shriever and a group of officers visited ABMA and were reported well pleased with what they saw. At the present time (mid-August) it appears that Secretary of Defence Wilson, who has announced his retirement in favour of McElroy, wants to decide the matter promptly, and has called a committee together in view of making a rapid decision.

The Army has naturally reacted strongly to the thought that its great Jupiter programme may be cancelled, and has continually fought for its point of view. In the midst of the dispute the well-known Nickerson court-martial occurred, which turned out to have had little or no effect. President Eisenhower gave no support to the Army's case when queried earlier this year, though the Army has considerable support on congress. Many experts feel, for example, that the Air Force has over-extended itself and has very few operational missiles and too many developments, pointing to the recent cancellation of Navaho as an example.

Wilson's rôles and missions memorandum specified that the Army should not consider any operational use of missiles over 200 miles, and it was noted that even if the Jupiter should win out over the Thor, the Air Force would take over operational responsibility. Press reports and trade journals have it that the Army has developed what have been called the Little B 800 mile ballistic missile and a Big B 2,000 mile ballistic missile, both currently unauthorized by the Wilson edict. The Army is particularly interested in getting formal permission for a medium range 600–800 mile development to fill a gap between Redstones and Jupiters, but has not brought up the user question as yet. In early August newspapers reported that the Army had built six of these medium range ballistic missiles (MRBM), but suggested that the Pentagon wondered where the money had come from. It is doubtful if such rockets have been built but the Army did admit carrying out "limited feasibility" studies of medium range missiles. The Aircraft Industries Association has spoken out strongly against the Army arsenal concept of development, desiring of course, that the government farm out most work to the airframe, engine, and related industries. Arsenals compete with industry, it was noted.

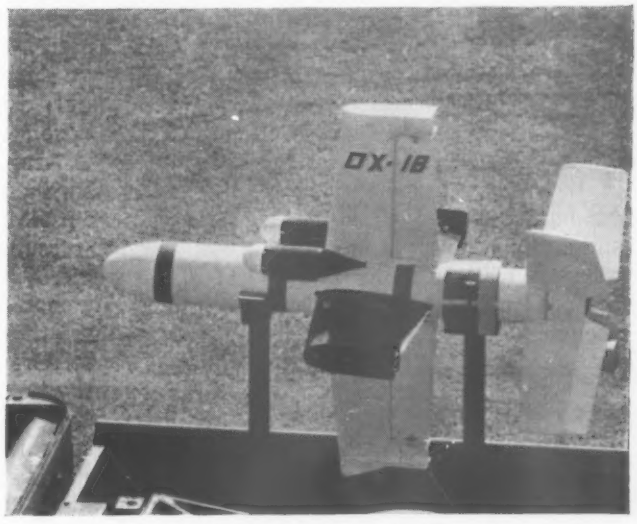


FIG. 2. Dart (U.S. Army photograph)

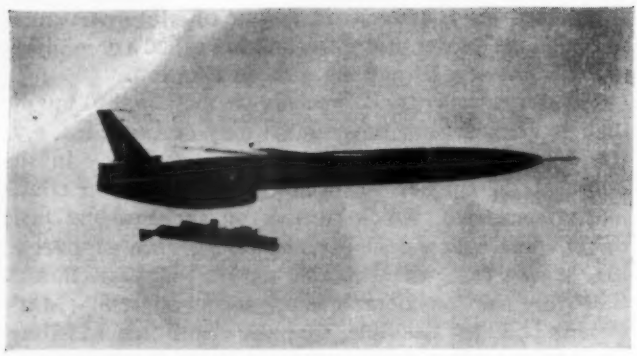


FIG. 3. Snark (Official U.S. Air Force photograph)

The Department of Defence has become acutely aware of the rising costs of armament in the United States, and has trimmed heavily in many areas. Ballistic missile developments have so far been exempted from economy cuts at the Defence level, but it is not known how long it will last. Rising costs may affect the receipt of missiles by Britain. According to reports, the U.S. had earlier thought that some $90,000,000 would be involved in turning over missiles to the U.K., but this may go to $240,000,000. Britain, in the meantime, was expected to pay $30,000,000 for site and other installation construction, but this figure may rise to $80,000,000. A reduced programme thus may result. As an example of rising expenditures, the Air Force expects to double its missile projects by 1962.

This is all seen against the backdrop of Soviet developments. Their IRBM is supposed to develop a sea level thrust of 275,000 pounds, and fly for nearly 1,000 miles, though some reports say 800, others 1,200. It may weigh 150,000 pounds loaded, and presumably has been fired in some quantity.

Army Artillery

What has been suspected for some time by many, and what recent events have confirmed, is that the Army is considerably further advanced in the surface-to-surface missile field than either of the other two services.

The performance of the Redstone-Sargeant three-stage rocket combination previously mentioned not only set world altitude and range records, but gave concrete evidence of the enormous progress made by the Army in the guided missile field. This Redstone-Sargeant combination showing is not far removed from the ICBM, and although this was an experimental firing, the results obtained will aid the current IRBM-ICBM studies. It has confirmed to many the belief that the Army should be one of the cognizant agencies controlling their development. At the present time, however, the Army has no control over the ICBM, and only a shaky hold on its IRBM.

The Ordnance Corps has made much progress since 1943, when it was given top cognizance over the Army's missile programme to provide increased fire power to artillery units. Projects include the Redstone, Corporal, Sargeant, Honest John, and Little John rockets. All of these weapons are either in or about to enter service.

In the anti-personnel, anti-tank, and anti-pill box fields, rocket weapons are also beginning to appear carrying such names as Dart and Lacrosse. The Army's imaginative and determined efforts to provide adequate means of defence and attack are securing missile leadership in the United States today.

Corporal

The Corporal missile, currently in service, is a ballistic weapon of no mean capability, having an atomic warhead and a range of 75 or more miles. It is basically an artillery piece launched vertically and guided by a radar beam, which renders the vehicle responsive to minor trajectory corrections during flight.

Among the existing operational battalions is one stationed in the Black Forest, Germany, and several other units are scattered throughout Europe. The organization of the Corporal into a missile system has resulted in an excellent fire power addition to the Army's long-range artillery.

About 250 specialists and G.I.'s go to make up a Corporal missile battalion. Their equipment is comprized of a launcher, erector, and guidance equipment, backed up by mobile facilities for servicing and maintaining the missile system. All major equipment is truck mounted, insuring maximum mobility. This is one of the missiles that Britain may receive as a result of confirmatory discussions held recently in Bermuda between the Prime Minister and President Eisenhower. It is believed that the first British guided missile regiment to be formed will be the 47th Guided Weapons Regiment (Field), Royal Artillery, and that it will test-fire the vehicles allocated to it from South Uist in the outer

FIG. 4. Honest John (U.S. Army photograph)

FIG. 5. Little John in flight (U.S. Army photograph)

Hebrides. British Army personnel are now here in Huntsville to become acquainted with the missile.

From the time of launch to the time the target is reached, a little less than 4 minutes passes. The Corporal has been night-fired with good results, and is considered an all-weather weapon. This capability, coupled with an atomic warhead, insures maximum effectiveness under the most adverse conditions. A Corporal battalion can, upon receipt of orders, move into new positions and get a missile off within 7 hours after arrival. Two to three missiles may be launched in 24 hours.

Honest John and Little John

The Honest John missile, also currently operational, was the result of a Douglas Aircraft Company proposal of 1950, at which time the Army Ordnance was entertaining bids on specifications it had previously prepared.

By 1951 test firings made at White Sands indicated that a very rapid development programme had been implemented by Douglas. More recently, operational units of the Army have fired practice rounds on Mt. Fuji, Japan, and also the Grafenwoehr training centre, Germany.

The Honest John, a finned, unguided vehicle, is 27 ft. long, 2½ ft. in diameter, weighs about 6,000 lb., and utilizes a solid fuel rocket motor. Since the missile is unguided, small rockets are mounted forward for the purpose of spinning the rocket slowly during flight to produce stability.

The self-contained mobile unit which erects and launches the rocket also provides the means of transport. At launching, the Honest John is oriented into its azimuth and elevation by the transport. This provides the only directional guide the missile has and is susceptible to very fine adjustments. Its CPE at 30 miles is about 150 yards.

Little John can be considered a short range miniaturized Honest John, weighing about 1,000 lb., and being 12 ft. long, it is approximately 1 ft. in diameter. It is guided in the same fashion as its big brother (by ground orientation only) and is propelled by a solid fuel rocket motor. It is an extremely mobile weapon, simple and accurate.

When this missile was conceived it was decided that the Redstone Arsenal should act in the capacity of prime contractor. Many of the requisite test firings have been accomplished, as the missile moves into field service.

The Dart and Lacrosse

The Dart and the Lacrosse are two short-range ballistic missiles, being used for anti-tank and anti-personnel attack, respectively. The Dart, a wire-guided weapon, employs a system previously developed by the Germans in World War II. It owes much to the current French SS-10 design.

This vehicle is 5 ft. long, 8 in. in diameter, with cruciform-type fins having a span of about 3 ft. At a recent Army showing of the Dart at the Aberdeen Proving Grounds, observers were very much impressed with the accuracy of the rocket. It can be fired from both stationary and moving positions, and its range is greater than weapons found on the modern tank. One man can fire and guide it.

Little information has been released on the Lacrosse, but scattered news items indicate that the vehicle has an all-weather command guidance system and is propelled by a solid fuel rocket motor. Reports suggest that a

FIG. 6. The U.S.A.F. test missile X17 (Official U.S. Air Force photograph)

FIG. 7. Lacrosse

high degree of accuracy has been obtained in its rôle as a close support and anti-pill box weapon. Guidance is handled by a forward observer.

Although Lacrosse is constructed by The Martin Company, the prime contractor is the Cornell Aeronautical Laboratories. Four swept-back wings and four fins suggest that the vehicle is well stabilized during its ballistic trajectory. Navy interest in the missile for supporting the landing of troops is also a project undergoing consideration.

Redstone and Jupiter

The Redstone missile was originally produced at the Redstone Arsenal, but is now in full production at Chrysler Corporation facilities. This missile, often considered a direct outgrowth of the V2, has a nuclear warhead, a 200–300 mile range, and high accuracy. As a tactical weapon in production, the Redstone knows no peer in the Western World. It is the first concrete step towards the long-range nuclear intermediate range, and intercontinental ballistic missiles.

A 75,000 lb. thrust North American liquid propellant rocket motor powers the giant 62 ft. vehicle. The body diameter is 5½ ft., and it has been reported that fewer specialists will be required to maintain and fire the Redstone than the number required to service the Corporal. The 217th Field Artillery Missile Battalion is currently undergoing training at the Redstone Arsenal, making it the first active unit to receive the vehicle for service use. The 40th Field Artillery Group will operate the missile under Third Army Command.

Powerplant and body are mated in a horizontal position by the use of a 25-ton crane. Following checkout, the missile is placed upright, and positioned by the crane on the launcher. Once alcohol, liquid oxygen and hydrogen peroxide are pumped into the proper tanks, and pre-flight checkouts have been made, the missile is ready and is levelled and turned on the launcher so that the stabilized platform is accurately oriented in terms of the target. Firing countdown can now begin.

The Redstone is vertically launched, and as it gains altitude it tilts towards its target. After motor cutoff, the entire propulsion assembly (about 75 per cent. of the vehicle's length) is dropped off, and guidance, controls and warhead continue (fin stabilized). The flight path is programmed into the missile, and play-back signals activate the guidance system in flight, assuring that the missile follows the pre-computed path to the target.

The Jupiter is currently the Army's only IRBM entry, although there is much speculation that it may grow into an ICBM later. If this is the case, it will be as much a triumph of politics as of technology and science.

Jupiter, which enjoys an advanced development status, has a 1,500-mile range capability. Information releases suggest that the Jupiter may employ a ground support set up similar to that of the Army's operating mobile platoon, consisting of a nine truck convoy. This would include a crane, auxiliary trailer fire control, and test truck, two missile trailers carrying the missile, three vehicles carrying propellants and an air compressor truck. Jupiter was a joint Army-Navy development, but the Navy recently withdrew support to concentrate on its new Polaris solid propellant Fleet Ballistic Missile.

FIG. 8. Redstone

On the third and fourth tries the Army was successful in firing the large Jupiter missile to distances in the neighbourhood of 1,500 miles. Maximum altitudes have been reported as between 250 and 300 miles. The earlier Jupiters had fuel slosh troubles, but these were quickly remedied. Difficulties with gas generator exhaust have also been solved. Jupiter development is being financed at the present time by a special Department of Defence fund. Army has made available between $140,000,000 and $175,000,000 on Jupiter to date, according to reports.

Air Force Ballistic and Jet-propelled Missiles

Determined efforts by the Air Force to provide an ever-increasing detriment to hostile action have resulted in main emphasis being placed on high-powered, long-range, retaliatory bomber aircraft. Be this as it may, ballistic missile programmes are becoming more and more prominent in Air Force planning, and it is not accidental that this service is attempting to hold its monopoly on these new vehicles of intercontinental range. The Strategic Air Command is already preparing for the day when it will have operational ICBM's under its command authority.

Air Force efforts in missilery, although not as spectacular as the Army's already-proven performance, are beginning to pay dividends. The Air Force, as seems to be logical, has concentrated much of its efforts on air-to-air missiles, bringing forth several highly advanced weapons systems of which they are justly proud.

Since they are the cognizant agency over both proposed ICBM's (Atlas and Titan) as well as one of three authorized IRBM's (Thor), their government allocations easily outstrip those available to the other two services (see table).

The Air Force began construction in late May on the nation's first strategic missile base at Cooke Air Force Base in California. There, ballistic missile handling and firing crews will be trained, including the 704th Strategic Missile Wing. Ballistic missile logistical support functions are now at Norton Air Force Base, also in California.

Matador

The Matador, probably the best known Air Force surface-to-surface weapon and certainly the oldest production vehicle in their missile stable, is an air-breather powered by an Allison J33A37 turbojet.

The vehicle is produced in two models, Model TM61A, a 600-mile range missile, and Model TM61B, a 650-mile plus missile. Radio-controlled Matador A weighs about 12,000 lb., has a thrust of 4,600 lb., and a velocity of Mach 0·9. The B model may have an inertial-celestial system, is longer and heavier than A, and will gradually replace it. The manufacturer (Martin Company) produces the missile in seven major parts. It is in large-scale production. Two other models (C and D) are becoming available now; C has the new Shanicle

FIG. 9. The big four: Nike, Honest John, Corporal, and Redstone missiles on display (U.S. Army photograph)

self-contained guidance system, and is in service with at least one wing.

The Matador is boosted by a J50 solid rocket from a zero-length mobile launcher. The range of the vehicle is limited by the guidance system and not the fuel capacity, as is usually the case. A price tag of $85,000 is often quoted. An operational Matador wing has some 3,000 officers and men to handle 18 missile launchers.

Navaho and Snark

Two Wright-Aeronautical ramjets with a thrust of 10,000 lb. provides sustainer power, and a North American liquid rocket gives each boost to the Navaho. It has a range of between 4,000 and 5,000 miles. A G26 test configuration of the Navaho missile recently flew 2,000 miles.

Not very long ago the XSM64 Navaho was earmarked U.S. $5,000,000, and somewhat later $21,000,000 for continued development. Then, in July, the Air Force announced that it was going to cancel this North American Aviation programme into which it had poured some $500,000,000 since 1946. Navaho is supposed to be a very complex missile, and nothing but failure marked a series of full-scale test firings that began in December, 1956. However, the Air Force thinks it has

derived an enormous amount of experience from the Navaho project, and by cancelling it is taking a gamble that its Snarks will do until Thors, Titans and Atlas' are in operational use.

The first Navaho had rate gyro trouble; the second lost booster thrust and its ramjets never ignited; boosters stopped completely on the third, and the missile burned up; and on the fourth, though its rockets brought the bird up to Mach 1·5, they subsequently malfunctioned, and this speed was too slow for the ramjets to cut on. There are some additional Navahos which are reportedly about ready for test, and it is expected that they will be flown.

Some of the questions asked by industrial sources are what is to become of Curtiss-Wright's 48-in. ramjets? Of North American's 120,000 lb. units allocated to the Navaho programme? And above all, of the 400,000 lb. thrust single chamber rocket engine which the company hoped would replace the three 120,000 lb. units? North American, because of the loss of both the missile and engine contracts, has had to lay off thousands of workers in recent weeks. Just what will happen to the X10 and G26 test vehicles for Navaho is not clear.

The Snark, another extremely long-range vehicle, has an estimated 12,000 lb. thrust supplied by a J57 engine, with boost given by two 33,000 lb. rockets. Northrup Aircraft Company is the prime contractor, and Pratt-Whitney provides the jet engine. This 74 ft. long, 4½ ft. diameter, 35,000 lb. vehicle is inertially guided with a star tracker and has flown over 3,000 miles on tests. Provisions have been made for additional auxiliary tanks to be carried and it is known that it can fit into the C124, C132 and C133 airplanes. Snark is launched from a sled. One errant missile crashed into the Brazilian jungle recently stirring up a considerable amount of press interest. An additional $73,000,000 has been awarded Northrop for its continued development. The Strategic Air Command is known to desire operational Snarks as soon as possible, and its officers are now being trained to operate it.

FIG. 10. Making final adjustments in preparation for fitting the Corporal (U.S. Army photograph)

IRBM's and ICBM's

Thor

The Air Force's intermediate-range Thor, designated WS135A, is being developed by the Douglas Aircraft Company. It has a North American Aviation liquid propellant rocket motor to provide the necessary thrust (the S3). This 1,500 mile IRBM's guidance system is manufactured by A-C Spark Plug Division of General Motors Corporation, drawing considerable aid from Packard-Bell Aircraft on the establishment of guidance stations. The Thor, a single stage vehicle, was recently test-fired only to abort on the pad. Much emphasis has been placed on interchangeability by the Air Force, resulting in the developing of components and systems which will also be used in the Titan and Atlas. Both Thor's and Titan's guidance packages are ready for vibration and acceleration tests at Navy's supersonic research track, China Lake, California.

Atlas

Despite the reluctance of the Defence Department to concentrate funds and research facilities on the Atlas project in the years 1950–54 (only U.S.$1,000,000 allocation per annum), and despite the dispersal of current funding (a subject of much contention) into several ICBM/IRBM programmes, the present development status of Atlas is steadily advancing to the first prototype vehicle.

The Atlas, a two-stage, 5,000 mile-range, Mach 15 ICBM, is being built by Convair at their new U.S.$41,000,000 Astronautics plant at San Diego. This facility will eventually employ upwards of 8,000 persons. A new $145,000,000 contract has been received for work on Atlas. The liquid propellent rocket motors for Atlas are being developed simultaneously by North American Aviation, who have already run several tests, and Aerojet-General, who are now installed in their 20,000 acre site near Sacramento, California.

The two motors powering the first stage will supply 100,000 lb. of thrust each for 3 minutes. The second stage will be powered for 12 minutes with 135,000 lb. of thrust, indicating that great space must be made available for fuel in the thirsty 100 ft. high giant. Warheads for Atlas and other Air Force ballistic missiles are made by Sandia Corporation.

Titan

Another 5,000 miles range thermonuclear weapon of the ICBM class is the Titan. This vehicle is to be constructed by The Martin Company in their new Denver

facility. The company has a $358,000,000 contract to develop and build the missile and 2,500 men assigned to the project.

It is known that the Titan, like the Atlas, will be a two-stage configuration. Aerojet and Reaction Motors will develop the powerplants. Although very little other information has been released to date, it has become obvious that a tremendous programme has been instigated on both ICBM projects.

ICBM Support

Vehicle re-entry and aerodynamic heating problems have necessitated a three-prong attack by Avco Manufacturing Company, Lockheed Aircraft Company, and General Electric Company to provide nose cone material and design solutions.

The Giannini Research Labs have developed a new plasma jet which brings temperatures into the 20,000° F. range, while General Electric has a water stabilized arc plasma whose temperatures go up to 26,000° F. Since an incoming ICBM at Mach 18 might have to handle 10,000 lb./ft.^{2} nose pressure, a boundary layer temperature of 10,000–15,000° F., and 1,000 BTU/ft.^{2}/sec. average heat transfer rate for nearly half a minute, it is obvious that this work is useful. The nose cone testing done by the X17 and NACA's four stage, Mach 10·4 hypersonic test vehicles is of vital importance to solving the complex re-entry problems. General Electric has a $158,000,000 nose cone contract, Avco one for $111,000,000.

It appears that the blunt nose is the best for keeping down aerodynamic heating, though many geometries have undergone test and evaluation. Since the blunt shape gives the lowest heat transfer rates, we presume it will be employed on the large IRBM and ICBM projects.

So much data and design information have been required for ICBM design projects, that several other allied programmes have been initiated to provide answers, one example being Lockheed Aircraft's X17 research missile.

The X17 consists of existing Sargeant solid propelled missiles assembled into a three-stage experimental vehicle. Of the first 20 fired, 17 behaved well, and one flew over 600 miles high to a range of more than 700 miles.

The Air Force authorities hope that this missile, which is currently in use at Patrick, will provide much of the required thermodynamic, separation, stability and design information required to supplement and support the ICBM programmes. The current velocity record of the X17 is 9,268 miles per hour. The X10, meanwhile, has been a successful jet-propelled test vehicle for the Navaho, and has been recovered up to 11 times for re-use.

Navy Developments

The Navy is by no means behind in the development of the nation's high performance missiles. Nuclear

FIG. 11. Martin Matador (Official U.S. Air Force photograph)

powered submarines, capable of launching missiles, constitute a powerful addition to the fleet's strength, bringing to bear tremendous firepower with maximum stealth. The Regulus, which is already in service on ten ships (four carriers, four cruisers, and two submarines), might be considered illustrative of the type of weapon which will be utilized in any future naval action.

Regulus

The Chance-Vought constructed Regulus, designated SSM-N-8, is an air-breather, being powered by a 4,600 lb. thrust, J33A18 Allison turbojet and boosted by two solid rockets manufactured by Aerojet-General. Successful launchings have been made from heavy and light surface ships, in some cases utilizing a new lightweight dolly-launcher replacing older equipment. The steam catapult (a British development) is being used on carriers to propel the missile and launcher (which is ejected into the sea at the end of the deck run).

The Regulus I is command-guided, and has a range of 300–500 miles; it weighs 14,500 lb., is 33 ft. long, and is capable of velocities in the order of Mach 1. Controlled landings have been made with this missile utilizing a tricycle type landing gear. Regulus II, a somewhat larger and heavier vehicle, is 57 ft. long, and has a range of between 800 and 1,000 miles. Estimates indicate that a speed of Mach 2 will be approached by this vehicle with its J79 General Electric powerplant and afterburner (it now uses a C-WJ65). The technique of landing the

missile has progressed to such an extent that it is now possible for the Navy to average four flights per missile.

Polaris

The new solid propelled Polaris IRBM is being developed for the Navy by Lockheed Aircraft Company, with the motor to be supplied by Aerojet-General and guidance by General Electric under supervision of Massachusetts Institute of Technology. It was long suspected that the Navy would leave the liquid propellent Jupiter programme it originally supported with the Army. While there were many objections to using liquid rockets on shipboard, one of them being liquid oxygen boil-off, it appeared that solutions were available for most. For example, efficient cooling-coil techniques were being perfected. Be this as it may, solid rocket proponents won out, and the Navy is on its own and will eventually have a Fleet Ballistic Missile with a range of some 1,500 miles. The first static test firings of the engine have already taken place.

One serious problem the Navy will have to tackle with the advancement of Polaris to operational status is that of accuracy. Navigational errors of even a few miles (which are common at sea) may land the missile many miles from the target. Undersea launching from submarine (another assignment for Polaris) will also accentuate navigational problems. The missile's inertial guidance package is reportedly passing through acceleration and vibration tests now, and a test stable platform and ship motion simulator are now being built. The Navy has $68,000,000 available for Polaris development.

Triton

The ramjet Triton may go the way of the Navaho—cancellation, though it is reported that the Navy wants to spend another $2,600,000 on the development of it. Triton came out of the APL-JHU Bumblebee programme, and is supposed to be progressing well. It has an inertial guidance system and is capable of flying 1,500 miles at speeds approaching Mach 3·5.

U.S. Defence Funding for Guided Missiles 1951–58
(Given in millions of dollars)

Service	1958	1957	1956	1955	1954	1953	1952	1951
Air Force	1,690	1,888	860	548	178	229	68	121
Army ..	673	743	354	350	317	122	191	35
Navy ..	465	440	233	117	139	154	141	119
Totals ..	2,828	3,071	1,447	1,015	634	505	400	275

Total Defence Funding 1951–58
Related to missiles and aircraft procurement
(Given in million of dollars)

Service	Missiles	Aircraft	Total Budget
Air Force ..	5,581,803 8·9%	46,070,012 73·2%	62,960,448
Army	2,784,045 10·6%	876,694 3·3%	26,173,561
Navy	1,808,082 5·2%	14,722,441 42·4%	34,735,995

Fiscal Year 1958

U.S. Department of Defence Funding for Procurement and Research and Development
(Given in millions of dollars)

	Missiles		Airplanes		Research and Development	
	A	B	A	B	A	B
Air Force	1,793	1,690	4,519	5,553	661	671
Army ..	425	673	82	124	400	400
Navy ..	428	465	1,631	1,696	505	505
Totals ..	2,646	2,828	6,323	7,373	1,651C	1,661C

Explanations:

A = New obligational authority, i.e. new money requested in the budget.

B = Planned obligations, i.e. new money plus money acquired from reimbursible obligations and previously unobligated balances.

C = These figures include Dept. of Defence research and development monies totalling U.S.$85,000,000.

Air Force Ballistic Missile Expenditures
(in millions of U.S. dollars)

Fiscal	1958	1957	1956
Ballistic missiles	676·9	659·4	267·0
Total ballistic missiles including support	955·7	882·4	307·9
Total missiles	1,950·5	2,168·8	997·4

(Note.—Do not attempt to add the first two lines to get the third. The second line includes the first, and the third includes all non-ballistic missile work.)

The Ballistic Missile Firing Record

	Name	Shot	Flight	Range
IRBM ..	Jupiter	1	Unsuccessful	
	Jupiter	2	Unsuccessful	
	Jupiter	3	Successful	~1,500
	Jupiter	4	Successful	~1,500
IRBM ..	Thor	1	Unsuccessful	
	Thor	2	Unsuccessful	
	Thor	3	Unsuccessful	
ICBM ..	Atlas	1	Unsuccessful	

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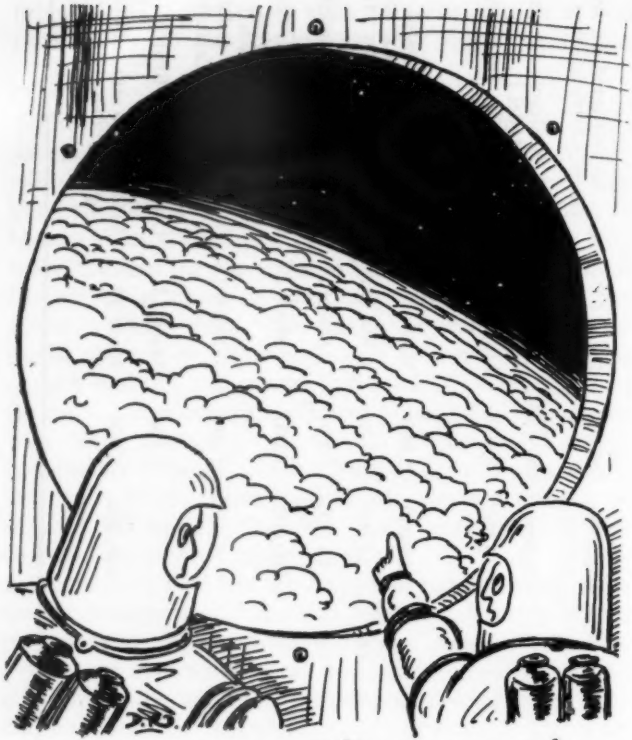
Current and Major Surface-to-Surface Missiles

	Designation	Cognizant Agency	Contractor	Power-plant	Powerplant Manufacturer	Thrust lb.	Length ft.	Diameter in.	Weight loaded lb.	Range miles	Velocity	Remarks
Army												
Corporal	SSM-A-17	Army Ord.	Firestone Tire	Liquid rocket	Aerojet, Ryan	20,000	40	30	12,000	75–150	Mach 3	Hundreds fired. In full Army service. Guided, atomic warhead.
Dart	SSM-A-23	Army Ord.	Aerophysics Utica-Bend	Solid rocket	Grand Central		5	8		5	650 m.p.h.	Wire-guided, anti-tank type, in production.
Honest John	M31	Army Ord.	Douglas A/C	Solid rocket	Hercules Powder		27	30	6,000	15–30		Unguided, free-flight. In service U.S.A., Japan, Europe.
Jupiter		Army Ord.	Chrysler	Liquid rocket	North American	135,000	60 (?)	90(?)		1,500	Mach 15	First U.S. successful IRBM. Good firing on third try.
Lacrosse	XSSM-A12	Army Ord.	Cornell Aero. Martin Co.	Solid rocket	Thiokol		20	20½		10–20		Tactical, close support, guided. In production.
Little John	XM-47	Army Ord.	Douglas Emerson	Solid rocket	Hercules Powder		12	12½	1,000(?)			First fired June, 1956.
Redstone	SSM-A-14	Army Ord.	Chrysler	Liquid rocket	North American	75,000	62	72	40,000	200–300	Mach 5	In service with 217th Missile Battalion. Air-transportable.
Sargeant		Army Ord.	JPL, Sperry	Solid rocket	Thiokol	~60,000	>30(?)	36	30,000	<150(?)		Has one of largest proven solid rocket motors existant.
Navy												
Polaris		Navy Bu. Ord.	Lockheed	Solid rocket	Aerojet		<50	100		1,000–1,500	Mach 15	Navy to spend $68,000,000 in 1958. Can be underwater launched.
Regulus I	SSM-N-8	Navy Bu. Aer.	Chance Vought	Turbojet	Allison	4,600	32	54	14,500	300–500	Mach 0·9	Can be recovered on test flight. Often sub-launched.
Regulus II	SSM-N-9	Navy Bu. Aer.	Chance Vought	Turbojet	General Electric	12,000	57	72	25,000(?)	800–1,000	Mach 1·5–2	Can carry atomic charge. Costs twice Model I.
Triton	XSSM-N-2	Navy Bu. Ord.	McDonnell	Ramjet	McDonnell		45	<60	20,000	1,500	Mach 3·5	Solid boosted. Inertially guided.
Air Force												
Atlas	WS 107-A	A.F.B.M.D.	Convair	Liquid rocket	North American	(1) 100,000 (2) 135,000 each	70	~100	>100,000	5,000	Mach 15	First firing unsuccessful. Top of trajectory approx. 800 miles.
Matador A	TM-61A	U.S.A.F.	Martin	Turbojet	Allison	4,600	39·5	54	12,000	620	<Mach 1	Solid rocket booster. In squadron and wing use.
Matador B	TM-61B	U.S.A.F.	Martin	Turbojet	Allison	4,600	45·8	54	<14,000	>650	<Mach 1	Higher altitude capability, improved guidance.
Navaho	XSM-64	U.S.A.F.	North American	Ramjet	Curtiss-Wright	20,000			<300,000	5,000	<Mach 3·5	Rocket boosted (360,000 lb. thrust NAA liquid engine). Programme cancelled.
Snark	SM-62	U.S.A.F.	Northrop	Turbojet	Pratt Whitney	11,000	74	54	35,000	5,000	<Mach 1	In production. Solid rocket boosted. Celestial-inertial guidance.
Thor	WS-135A	A.F.B.M.D.	Douglas	Liquid rocket	North American	135,000				1,500	Mach 15	Unsuccessfully fired three times. An IRBM.
Titan	WS-107B	A.F.B.M.D.	Martin	Liquid rocket	Aerojet Reaction Motors	(1) 300,000 (2) 60,000	~100		>100,000	5,000	Mach 15	$358,000,000 allotted to its development; two-stage.



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Space Buccaneers

An American general told reporters recently that it might be considered a logical step to launch modified I.C.B.M.'s towards the Moon as part of the Air Force training programme for I.C.B.M. launching crews; now. . . .

The great moment has arrived. An unmanned rocket is en-route to the Moon. The small spherical body, its braking rockets angled downwards, drops towards the cratered surface of our satellite; then, suddenly, from a container beneath the rocket a javelin-like flagpole shoots down to pierce the lunar terrain, carrying at its mast-head the Stars and Stripes.

America has claimed the Moon !

Believe it or not, this is not the latest effort in juvenile science-fiction but the serious suggestion of Pierre J. Huss which appears in an illustrated feature, "Let's Claim the Moon—Now !" in the May issue of *Mechanix Illustrated* (International edition).

"The Russians, by their own admission, are getting ready to claim possession of the Moon," declares Huss; ". . . now is the time for the U.S. Government to act boldly. Congress should issue an immediate proclamation establishing jurisdiction over the Moon by right of first contact. The flag could follow as the clincher."

But Mr. Huss goes further: "The first contact," he says, "and even the Russians haven't claimed this—was made with the Moon by the United States Signal Corps on January 10, 1946. Lieutenant-Colonel John H. DeWitt made the historic contact by radar at Evans Signal Laboratory, Belmar, N.J. . . . Here, then, is the first legal basis on which the United States Government can pin a technical claim of jurisdiction."

". . . the risk of America losing the race into space," Huss continues, "and therewith the honour of first reaching the Moon seems to be very great. So why don't we start *now* by making a giant effort to plant the U.S. flag on the Moon through a series of rocket shots?"

"Now is the time," the article concludes, for us to stake out our claim to the Moon if the interests of free mankind are to be safeguarded . . . otherwise, the Reds will beat us to the punch."

With what seriousness this article was received by American readers it is difficult to tell, though it is surprising to find alongside the feature the following note by the editor of the International Edition: "We realize that this is an article in which the 'American Angle' is pretty overwhelming. Nevertheless it seems to us to be of such general interest that we present it just as it appeared in the American edition of *Mechanix Illustrated*."

To Mr. Huss, the editors of this magazine and all potential space-buccaneers, may we recommend the more adult approach of international law, as exemplified by the writings of fellow-American Andrew G. Haley (*e.g.* "Space Law and Meta-Law," presented at the 7th Annual Congress of the International Astronautical Federation, Rome, September, 1956)? K. W. GATLAND

The Young Astronaut's Library

By W. E. KESWALL, M.A.

Perhaps because I am headmaster of a school, I have more than my fair share of enquiries as to suitable books for those who are interested in spaceflight and astronomy (or should it be "astronomy and spaceflight"?) and it may be of use to give some comments, based upon my own experience of what is likely to instruct and interest those who want to learn, but have little positive knowledge. It must be remembered that what will interest the keen young reader will also interest the keen adult, and in the list which follows I have been careful to exclude books which require definite specialized knowledge.

The first essential is a book which gives an accurate grounding in general astronomy, since without this it is not possible to appreciate the problems of astronautics. R. A. Lyttleton's *The Modern Universe* (Hodder & Stoughton, 1957) is suitable for all classes of reader, and so is Sir Harold Spencer Jones' *Worlds Without End* (English Universities Press, £954). W. Buedeler's *To Other Worlds* (Burke, 1955) is also very useful, as it combines the fundamentals of astronomy with those of rocketry. Specifically written for boys is a new book by H. P. Wilkins, *Instructions to Young Astronomers*, which is not nearly so forbidding as one might imagine from its title, and for the practically-minded *Handbook of The Heavens*, by Bernhard, Bennett and Rice (Mentor Books, 1956) is useful. Slightly more technical is *Introduction to Astronomy*, by Cecilia Payne-Gaposchkin (Eyre & Spottiswoode, 1956). I had always regarded this as rather "a mouthful" for a reader in his mid-teens, but after introducing it into my school library I found that my judgment had been somewhat at fault, as it proved very popular indeed.

Secondly, we need a book which concentrates on the fundamentals of astronautics. There is no doubt in my mind that the best of all is *The Exploration of Space*, by Arthur C. Clarke (Temple Press, 1954). This relies upon a clear, interestingly-written text, and not upon gaudy pictures; though decidedly adult, it can be understood by any intelligent boy. For this reason, I far prefer it to the lavishly-illustrated coloured books imported from America. Clarke's *The Young Traveller in Space* (Phoenix House, 1954) is likewise probably the best introduction aimed specifically at those of school age, though it is rivalled by some other books, notably W. F. Temple's *Space Travel* (Muller, True Books, 1954) and Patrick Moore's *The Boy's Book of Space*, which is more astronomical (Burke, 1954). *The Adventure of Space Travel*, by G. V. E. Thompson (Dobson, 1954) is excellent, and contains the best elementary account of the rocket engine known to me, while Eric Burgess's *Introduction to Rockets and Spaceflight* (Hodder & Stoughton, 1956) is also very clear. All these are in my school library, and there is a waiting list for each.

The next requirement is probably to learn something about the worlds we hope to visit. First on our list comes the Moon, and all the necessary information can be found in Patrick Moore's *Guide to the Moon* (Collins, 1957), which has the additional merit from a schoolboy's point of view—of being a half-crown paperback, and therefore very cheap to buy. The only comparable volume, also very good, is H. P. Wilkins' *Our Moon* (Muller, 1953), which has excellent photographs.

General volumes on the planets are relatively numerous. Again we have a paperback by Patrick Moore, *Guide to the Planets* (Collins, 1957); like its companion Guide, it was originally published as a hard-bound volume in 1953, and it is a particularly informative work as well as being easy reading. Equally good is *Man and the Planets*, by R. S. Richardson (Muller, 1954). Dealing with the planets in general, though in a slightly different way, is *Life on Other Worlds*, by Sir Harold Spencer Jones (English Universities Press, 1956), recommended as an excellent corrective to the usual "comic papers" which depict strange life forms on Mars, Venus and elsewhere.

Books on Mars are plentiful, and have been reviewed by Dr. Slater in No. 1 of *Spaceflight*, so that it is not necessary to describe them here. Venus has only one book devoted to it: *The Planet Venus*, by Patrick Moore (Faber & Faber, 1956). Here is an accurate, most informative account of all that is known of Venus, and though it was written for adult readers, and has an extensive reference list, it is popular among my Sixth Formers.

Having mastered the fundamentals, we can turn to more limited books—limited in scope, that is to say, not in the amount of information imparted. In the near future we may expect several books dealing with the Earth Satellite programme; since these are not yet available it would, of course, be wrong to discuss them, but I understand that a volume by Arthur C. Clarke, *The Making of a Moon*, will appear shortly (Muller). The historical side of astronautics is best dealt with by Willey Ley in his *Rockets, Missiles and Space-Travel* (Chapman & Hall, 1953), which is regarded, rightly, as the standard work in this field. The story of the German effort is given in V-2, by W. Dornberger (Hurst & Blackett, 1953), and the Viking programme by Milton Rosen in *The Viking Rocket Story* (Faber & Faber, 1956). The upper-atmosphere programme is excellently dealt with by Eric Burgess in *Frontier to Space* (Chapman & Hall,

[*Continued on p. 188, col. 2.*

Correspondence

SIR,—Mr. Morris's letter defending space-stations against statements in *Space Encyclopædia*, prompts me to comment. First, I do not agree with Mr. Bizony's wholesale condemnation of manned space-stations as useless and uneconomic. On the other hand, I do agree that some of the proposed uses for a space-station are of doubtful utility.

To begin with, there is Mr. Bizony's statement that a manned space-station would be "ludicrously uneconomic". This, I have reason to believe, means that Mr. Bizony has considered all the proposed uses but concludes that the sum total of services and gains in knowledge are not worth the cost. My view is that we are not in a position to dogmatize about what our descendents will consider too costly, any more than we are in a position to condemn, in retrospect, the ancient Egyptians for pyramid-building.

Next, there is Mr. Bizony's denial of the military value of a space-station. On this point I agree with him. Despite all that has been said in support of a space station's military worth, I am of the opinion that the counter-arguments of its vulnerability and destructibility prevail. Furthermore, I consider that the existence of an armed space-station would not be a deterrent to war but an irritant likely to provoke conflict. In any case, I oppose as a matter of principle the furtherance of astronautical ventures by offering military enticements.

I am unable to determine whether "a large number of relay stations could be built for the equivalent cost"—that would seem dependent upon the services provided by the relays, and their reliability if unattended. Omitting the qualification "large" might make the contention more acceptable.

Regarding the proposal to use a space-station as a refuelling depôt, I would say this: it is not *necessary*; however, if a station exists for other purposes, then it *could* be used to store fuel. But I am at a loss to understand what makes Mr. Bizony so certain that orbital refuelling will be obsolete before the building of a space-station becomes possible. I wish I knew the future history of astronautics as well as he claims to do. On the other hand, I disagree with Mr. Morris' "many scientists" that a journey to the Moon will not be accomplished without a space-station. At any rate I disagree to the point of seeing no fundamental bar.

I think it is true to say, that a number of observations and research programmes proposed for a space-station could be carried out equally well on the Moon. But which comes first?—the space station or a base on the Moon? I for one do not know. However, in any case, to cite one item in favour of a space-station, zero-gravity conditions are not obtainable on the Moon: in a space-station they are. Again, certain meteorological observations of the Earth require a close polar orbit, which, of course, the Moon does not provide.

It may seem strange that, having collaborated in the design of a manned space-station of no mean elaboration, I have some doubts about them. It might well be expected that I would decry all criticism of their utility and passionately affirm my belief that they are an indispensible step in the conquest of space. The following statements may clarify my attitude:—

The design to which I contributed was undertaken with the intention of showing what *could* be done, not what *will* be done. Moreover, I believe that the establishment and maintenance of a giant manned space-station contains technical and engineering difficulties which are unlikely to be overcome until many years hence. However, if in due course such structures are deemed worthwhile, then I have no doubt they will be built.

Yours faithfully,

14, Wooburn Green Lane,
Holtspur, Beaconsfield, Bucks.
H. E. Ross

July 13, 1957

Continued from p. 187.

1955); perhaps a little technical for the younger reader, but still useful, while for the adult it is invaluable. Medical problems of spaceflight are described by Heinz Haber in *Man in Space* (Sidgwick & Jackson, 1955)—complete with some humorous illustrations which lighten the book and add to its attraction.

I have said little about the "coloured picture" books, since for the reasons I have given I prefer books which rely upon good texts, but I cannot omit *The Exploration of the Moon* (R. A. Smith and A. C. Clarke (Muller, 1955)), since the text is as good as the plates. It is admittedly speculative, but the speculation is always well controlled.

It will be appreciated that in this short survey, I have had to confine myself to elementary books which I myself know, and can recommend from personal experience of their popularity in my own school library: the list is far from complete. Remember, too, that although some of these books are expensive, it is always possible to borrow them from any local Public Library, and if the Librarian does not already possess them he will ensure that they are obtained for you. I do not feel that enough use is made of Public Libraries; they are there to be of service, and they are always only too willing to be helpful.

The Firestreak

Details have recently been given of the *Firestreak*, an air-to-air missile developed by de Havilland Propellers Ltd., primarily for fitting to the English Electric "P1" and the Gloster "Javelin" fighters. The Company originally developed the missile as a weapon with a guidance system which would enable it to engage high-speed aircraft at great heights, an infra-red target homing system is employed, as this gives the important factors of great range coupled with high sensitivity and is immune from the various forms of jamming that can be used to counter conventional radar systems. The "Firestreak" employs a detector eye which is sensitive to infra-red rays emitted from modern jet aircraft; this eye once it has locked on to the target aircraft, feeds information into the control system to ensure that it constantly travels in the correct direction and cannot be outmanœuvred.

The components of the *Firestreak* fall into six main sections, these being guidance control and fusing systems, power supply, rocket motor and warhead, all six being housed in the body tube which is fitted with four stub wings and four rear-mounted control fins.

The missile is launched from zero length launching shoes attached to the wing of the aircraft, and can be launched singly or in pairs, besides being readily jettisonable in event of an emergency.

The first free flight trials were carried out from ground launchers at the Royal Artillery range at Larkhill, and after initial tests to check booster separation, a number of weapons with turbo-alternator installed to check the performance of the power system under the high stresses during flight, the information being telemetered back to the ground station, as the missiles were destroyed during flight for reasons of safety. The first aircraft firings were carried out over the Aberporth range with the aid of Venom aircraft, initially for testing launching and jettisoning techniques and subsequently to test the missile against radio controlled target aircraft which were fitted with heaters to simulate the heat output of modern jet aircraft.

Due to the restricted size of the Aberporth range the high-speed target testings programme was conducted at the Woomera range in which firings were made from Australian-built Sabre aircraft against Jindivik target aircraft. It has been proved during these tests that the *Firestreak* is suitable for both sub- and super-sonic launching giving a high percentage of target kills.

In addition to the aircraft mentioned above, the *Firestreak* will be fitted as standard to the de Havilland Sea Vixen.

Several thousand people are now employed in producing the missile for the R.A.F. at the Hatfield and Walkden factories, and a third factory is being built in the Lancashire area also for this purpose.

The Firestreak, *an air-to-air guided weapon designed by de Havilland Propellers Ltd. and for which a production order has been placed. The photograph was taken by a camera mounted on the wing of the parent aircraft, which was flying at great height, and shows* Firestreak *accelerating rapidly immediately after launching*

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From the contents of No. 2, Vol. VIII (1957)

Straight Rocket Combustion Chambers (H.v. Zborowski); *Rockets, Missiles, Satellites* (A. J. Zaehringer); *Hydrogen Peroxyde or Nitric Acid?* (H. Schneider); *Scientific Results and Economical Effects of the Realization of Space Flight* (W. Trommsdorff); *Space Law* (A. G. Haley); *Combustion Processes in Rocket Combustion Chambers* (E. F. Büchner).

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USAF Scroll of Appreciation to Phillips Petroleum Co.

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A Scroll of Appreciation was presented by the U.S.A.F. to Phillips Petroleum Co. recently in a special ceremony at Bartlesville, Oklahoma, for outstanding service in the field of solid-propellant rockets from 1951 to date. During this period the Company developed a variety of solid-propellents, including a "king-sized" rocket which produced the highest thrust ever attained by a single rocket motor, either liquid or solid. The basic ingredients for these solid propellants consist of materials such as ammonium nitrate (commercial fertilizer), synthetic rubber, carbon black and other ingredients which can be manufactured from petroleum raw materials, of which the Company is a major supplier. Among its projects is the M15 JATO rocket, a 16-sec. 1,000-lb. thrust solid-propellant rocket which represents the first commercially successful use of ammonium nitrate as the oxidizer.

The Rocket Fuels Division of the Company is contractor-operator of the U.S.A.F. Plant No. 66, a modern 12,000 (Government-owned) plant with extensive facilities for applied research, development, testing and manufacture of such rockets. The development facilities include a well-equipped laboratory for bench-scale experimentation, a completely integrated pilot-plant for full-scale development studies and a pilot line for comprehensive studies of manufacturing techniques and small production programme. There is a proving ground with test facilities for rocket engines of up to 1,000,000 lb. thrust, besides the usual maintenance shops, storage facilities, warehouses, administration buildings, etc., with plenty of space on the site for future development.

The Rocket Fuels Division employs at present some 200 scientists and technicians, but they can also call on the other departments of this vast concern.

Besides producing a rocket having the highest known thrust, the Company has also produced one which has the longest known duration.

North American X-15

Fabrication has begun on the U.S.A.F. X-15 rocket-powered research airplane at the Los Angeles plant of North American Aviation, Inc. Raymond H. Rice, Vice-President and General Manager of the Los Angeles Division of the Company, said recently that wind-tunnel tests are nearly complete, and although specifications are classified, the engine's thrust will be greater than the thrust rating of the X-1 and X-2 series of aircraft, which have flown at speeds exceeding 1,650 m.p.h. and have attained altitudes greater than 90,000 feet.

The X-15 project began following preliminary studies by N.A.C.A. to determine the feasibility of developing a research aircraft beyond the flight levels of the X-1, X-2 series, and a co-operative programme was drawn up between the U.S.A.F., N.A.C.A. and the U.S.N., development responsibility being given to the Research and Development Command of the U.S.A.F.

North American Aviation were awarded the contract for the development and fabrication of the X-15, while development of the aircraft's liquid-propellant rocket motor is being undertaken by Reaction Motors, Inc., Denville, New Jersey.

L. J. CARTER

MEETINGS OF THE YORKSHIRE BRANCH AN ALTERATION

Members of the Yorkshire Branch are asked to note an alteration in the programme of lectures to be held at the B.I.S. Observatory, Harlow Tower, Harrogate. Lt.-Col. G. E. B. Stephenson's "Telescope Making" will now be delivered on October 19, 1957, and Patrick Moore's "Observing the Planets" on November 9, 1957.

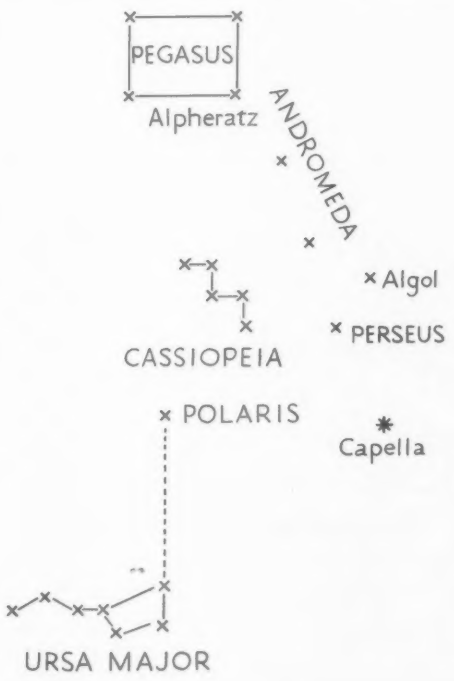
L. S. STRICKSON

Sky Diary: October to December, 1957

By GEOFFREY TURNER, F.R.A.S.

Although astronomy is not a "seasonal" occupation, dark nights offer better opportunities for celestial studies, and moreover the winter skies in Britain are more interesting than those of summer. Ursa Major, the Great Bear, is to be seen in the northern sky at this time of the year, at a lower altitude than the Pole Star. It is always a "signpost" in the sky, and we can easily find the W-shaped constellation of Cassiopeia by looking on the side of Ursa Major opposite to the Pole Star (Polaris). Further away from Polaris, slightly to the east, we find the Square of Pegasus. Actually one of the Square stars really belongs to the neighbouring constellation Andromeda, while not far off is Perseus. These three groups are near the zenith about midnight during September, October and November respectively.

There are many interesting objects in these constellations. One of the strongest radio sources in the sky lies in Cassiopeia; it can be studied only by radio telescopes. It is thought to be the remnants of the supernova observed by the Danish astronomer Tycho Brahe in 1572, but proof is lacking. In Andromeda we have the brightest of the extragalactic nebulæ, M.31, which can be seen with the unaided eye, appearing as a faint fuzzy patch. Perseus contains the most famous of all "variable" stars, Algol, which is normally of magnitude 2·3, but drops down to 3·5 when it is suffering eclipse. Algol is not truly variable, but is better called an eclipsing binary. Among other stellar objects, mention must be made of the Pleiades, in Taurus, known commonly as the Seven Sisters, while the double star-cluster in Perseus can also be seen without a telescope.



The outer planets are not well placed for observation at present. Jupiter is a morning star, and Saturn sets soon after the Sun—after the second week in December it sets before the Sun. Mars rises just before 6.0 hours G.M.T. However, Venus is better placed. It moves through Libra, Virgo, Sagittarius and Capricornus during the period, and though it is south of the celestial equator it sets as much as 3 hours after the Sun in Britain in the later part of the year. Serious studies of it are best carried out in daylight or dusk As Venus approaches the Earth, its phase changes and its angular diameter grows; the loss in brightness due to the diminishing phase is more than offset by the great increase due to its growing size, and it is actually at its most brilliant on December 24, though by then it will be past elongation. The other inner planet, Mercury, will set an hour after the Sun in early December, but will be close to the western horizon.

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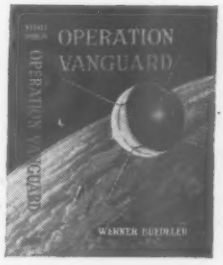

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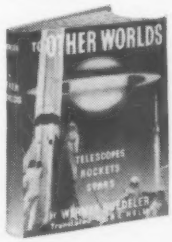

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Reviews

The Rocket Pioneers. By Beryl Williams and Samuel Epstein. Lutterworth Press, 1957. Price 15s.

Here, well illustrated with photographs of historic interest, is a popular and eminently readable book about some of the precursors of the space age, notably William Congreve, Jules Verne, K. E. Ziolkovsky, Robert H. Goddard, and Hermann Oberth. In subsequent chapters, attention is given in considerable detail to the story of the *Verein für Raumschiffahrt*, the American Rocket Society, and what the authors term the Peenemünde Group. A brief reference to the British Interplanetary Society is also to be found—as is an account (on page 169, and again on page 205) of this reviewer's early encounters with Willy Ley. P. E. CLEATOR

A Space Traveller's Guide to Mars. By Dr. I. M. Levitt. 146 pp. + two appendices, bibliography, glossary and index; 8 plates. Gollancz, 1957. 16s. nett.

Dr. Levitt is director of the Fels Planetarium, Philadelphia, and as such is obviously accustomed to presenting astronomy to the public. In this work, he makes a very entertaining survey of our present knowledge of the planet Mars, more it must be confessed, from the point of view of the armchair astronaut than the rocket engineer, but at least it is a relief to find a writer on astronomy who treats space travel as the quite natural and inevitable extension of man's attempt to get to grips with the universe he lives in, rather than with the contemptuous conservatism or unscientific idealism of astronomers royal and hack fiction writers respectively.

The first five chapters of Dr. Levitt's book are devoted to introducing Mars: all the familiar topics are dealt with in sufficient detail and the author gives a very fair summing up of the canal problem and the evidence for and against life on Mars. This leads him to consider the wider problems of life in the universe as a whole, the last two chapters being devoted to tracing the origin and evolution of the universe from the time-horizon onwards.

This, unfortunately, is the least satisfactory part of the book, because Dr. Levitt puts forward in an entirely uncritical manner merely one cosmogonical hypothesis, the Ylem idea of Gamow. (Ylem is supposed to be the primordial, pre-expansion store of pure radiation out of which all the present matter of the universe was created.) Whatever the merits of this hypothesis may or may not be, it should not be produced blandly out of the blue as a fact without a word of warning to the unwary reader. Popularisers of astronomy would do well not to rush in with dogmas where the professional treads with considerable trepidation. This section of the book reads more like a modern mythological cosmogony than a scientific exposition.

Fortunately, in his discussion of the many theories of the origin of the Solar System, the possible origin and development of simple life forms, and the present condition of the planets, the author returns to the more rational manner of the excellent earlier chapters. He concludes that from statistical considerations alone, life must be present throughout the universe, in all forms and stages of development.

The text is rounded off by a further discussion of the way in which life may have originated (again too uncritical) and an attempt to formulate a Martian calendar.

Less technical than Vaucouleurs' *Physics of the Planet Mars*, wider in scope than the latter's *The Planet Mars*, less specialized than Strughold's *The Green and Red Planet*, less directed towards the amateur observer than Moore's *Guide to Mars*, this present work strikes its own original note. When the author remains on his stated topic—the planet Mars—he is excellent; when he widens out, the reader should take him with a pinch of salt. The general impression left with this reviewer, however, was of a stimulating and interesting book.

Incidentally, the great German physicist's name is Weizsäcker, not Weizsacher, as Dr. Levitt would have us believe; and it would not be possible for a man to jump off either of the Martian satellites by the power of his muscles alone. The critical diameter for this would be about 2½ miles, assuming normal density. MICHAEL GUEST

Guide to I.G.Y. Various authors. Methuen, 1957. 48 pp. 2s. 6d.

This excellent booklet deals with all departments of the International Geophysical Year. There are 16 short sections, each written by a relevant expert; contributors include M. A. Ellison, T. Gold, James Paton, Sir Harold Spencer Jones and H. S. W. Massey, while there is a Foreword by Sir James Wordie. The writing is clear; the print and presentation good, and the photographs well chosen and reproduced. There are excellent line drawings, and the few misprints are very minor.

The only real criticism concerns the last section, "Suggestions for Simple Observational Work", by W. Llowarch, which is definitely below the standard of the rest of the booklet; it is stated that it is safe to observe the Sun directly by means of a telescope and a dark eyepiece-cap, which is actually most dangerous, and the author describes ordinary sunspot projection and the construction of a magnetograph—yet he does not mention Moonwatch, which is the one way in which the amateur may really be able to make himself useful!

This short section apart, the booklet may be highly recommended. It has the additional merit of a low price.

K. SIMONS

Operation Vanguard. By Werner Buedeler. Burke Publishing Co., 1957. 128 pages. Price 16s.

This is a book devoted largely to the new satellite projects, although there is a brief introduction devoted to earlier work. There are seven chapters: A New Age Begins, Into the Sky, Artificial Satellites, Laboratories at Very High Altitudes, How the Satellites will Pay their Way, Satellites of the Future, and Man and Space-flight. The last of these chapters is short and restrained; in fact, there is very little speculation anywhere in the text.

The book is an excellent one; clearly and smoothly written, full of information, accurate and attractive. The illustrations are well-chosen, and are very up-to-date. The author must be congratulated upon a very useful and timely addition to the literature of satellite research. He has been very well served by his translator, A. L. Helm. H. W.

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